ASTM Bulletin

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IN NUCLEAR ENERGY FIELD

Chicago, Ill. April 16-18

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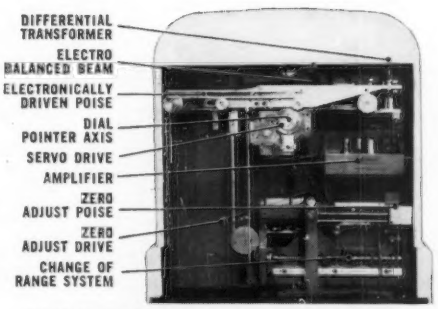

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ASTM BULLETIN

FEBRUARY 1957

Number 220

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ASTM Bulletin is available on microfilm from University Microfilms, Ann Arbor Mich.

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ASTM Bulletin, February 1957. Published eight times a year, January, February, April, May, July, September, October, and December, by the American Society for Testing Materials. Publication Office—20th and Northampton Sts., Easton, Pa. Editorial and advertising offices at the headquarters of the Society, 1916 Race St., Philadelphia 3, Pa. Subscriptions, United States and possessions, one year, $2.75, two years, $4.75, three years, $6.50; Canada, one year, $3.25; two years, $5.75, three years, $8.00. Other countries, one year, $3.75, two years, $6.75; three years, $9.50. Single Copies—50 cents. Number 220. Entered as second class matter, April 8, 1940, at the post office at Easton, Pa., under the act of March 3, 1879.
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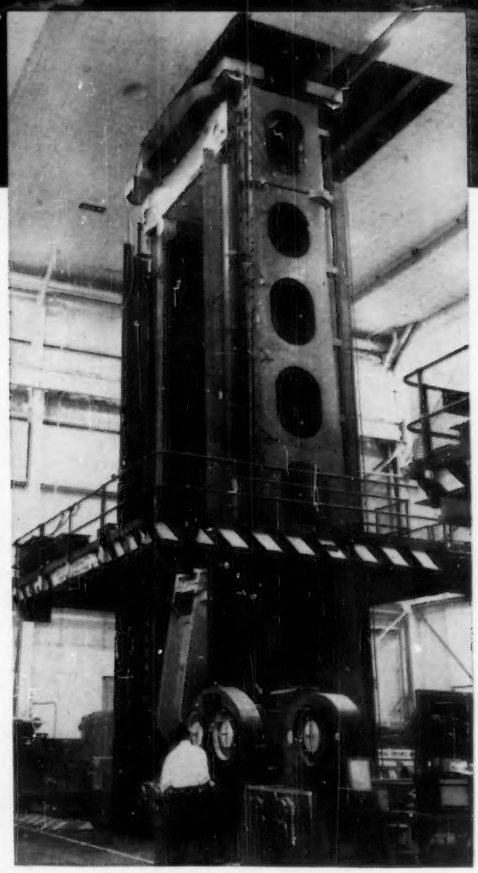

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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

Number 220 **February 1957**

Annual Meeting Symposia

On radiation effects on materials—dissolved oxygen in water—large fatigue testing machines —gases and metals—spectrographic analysis for trace elements

THE 60th Annual Meeting of the Society, which will convene June 16–21 in Atlantic City, N. J., promises a technical program of the scientific diversity that has come to be expected of ASTM gatherings.

The program, now beginning to take form, will schedule five symposia as well as a week-filling number of sessions of papers on related subjects. All sessions, symposia, and others, will provide ample opportunity for discussion. As in the past, participation by the audience with its resulting enrichment of the meetings, will be encouraged by the preprinting of as many papers and reports as it is possible to handle. Members will be advised of the availability of reprints in the spring.

1957 Honor Lectures

The two memorial lectures—honoring Edgar Marburg and H. W. Gillett—will be given by Everett P. Partridge and Alvin J. Herzig.

Mr. Partridge, director of Hall Laboratories Inc., will speak on the subject of water. Mr. Herzig, who is president of Climax Molybdenum Co. of Michigan, will take up the timely topics of molybdenum and columbium.

Members will find the advance provisional program of the meeting in their April issue of the ASTM BULLETIN—complete with time, place, and abstracts of the scores of papers which will be presented. With this program they will be able to plan their visit to the meeting either for a few days or the entire week and to get their reservations in early for the Headquarters Hotel, Chalfonte-Haddon Hall, or any of the numerous cooperating hostelries. The advance program will also contain information on the social events and ladies entertainment planned by the hosts of the meeting—the Philadelphia District.

Titles and authors of the papers of three symposia are given below in as complete detail as is now available.

Symposium on Radiation Effects on Materials

Cosponsored by Subcommittee on Radiation Effects of the Atomic Industrial Forum and ASTM Committee E-10 on Radioisotopes and Radiation Effects

I. Consideration of Radiation Effects in Design

Systems Consideration Affecting Selection of Structural Materials for Nuclear Power Plant Components—*W. L. Fleischman, KAPL.*

Influence of Radiation Effects on Pressure Vessel Design—*M. A. Cordovi, Babcock and Wilcox Co.*

Problems in the Standardization of Techniques in the Irradiation Effect Studies—*M. J. Feldman and R. H. Fillum, Westinghouse Electric Corp., APD.*

II. Radiation Facilities and Techniques

Application of the Battelle Research Reactor to Radiation-Effects Studies—*J. W. Chastain, BMI.*

A Technique for Measurement of the Electrical Resistivity of Radioactive Materials—*C. L. Boyd.*

Techniques for Making Visual Examinations and Dimensional Measurements at Hanford's Radiometallurgy Laboratory—*D. L. Zimmerman.*

III. Radiation-Effects Studies of Materials

Effect of Heat-treatment and Burn-up on the Properties of a Nuclear Fuel—*D. O. Leeser, APDA and G. D. Calkins, BMI.*

Engineering Effects of Radiation on Nuclear Fuels—*B. Lustman, WAPD.*

A Survey of the Radiation Stability of Hydrocarbon Fuels—*R. O. Bolt, J. G. Carroll, and J. A. Bert, California Research Corp.*

Selection of Organic Materials as Reactor Coolant-Moderators—*E. L. Colichman and H. R. J. Gercke, Atomics International.*

Effects of Radiation on Protective Coatings—*J. C. Bresee, ORNL.*

Effects of Radiation on Electronic Components—*G. J. Rotariu, Cook Electric.*

Symposium on Determination of Dissolved Oxygen in Water

Sponsored by Committee D-19 on Industrial Water

A Study of the Accuracy of Methods of Testing for Dissolved Oxygen in High Purity Water—*K. G. Stoffer, Arabian American Oil Co.*

The Beckman Oxygen Analyzer—*Thomas Finnegan, Niagara Mohawk Power Corp.*

Polarographic Measurement of Dissolved Oxygen—*W. W. Eckenfelder, Jr., Manhattan College.*

Evaluation of Hartmann and Braun Dissolved Oxygen Recorder—*A. J. Ristaino and A. A. Dominick, U. S. Naval Engineering Experiment Station.*

Determination of Dissolved Oxygen by Means of the Cambridge Analyzer—*H. A. Grabowski, Combustion Engineering, Inc.*

Symposium on Large Fatigue Testing Machines and Their Results

Sponsored by Committee E-9 on Fatigue

Large Fatigue-Testing Machine for Automobile Springs—*S. A. Gordon, Battelle Memorial Institute.*

A Unique Machine for Large Scale Fatigue Testing—*H. V. Cordiano, New York Naval Shipyard.*

Fatigue Performance of Marine Shafting—Laboratory and Service Tests—*T. W. Bunyan, Lloyd's Register of Shipping.*

A Hydraulic Fatigue Machine Designed to Test Relatively Large Sections—*E. J. Eckert, Caterpillar Tractor Co.*

Fatigue Testing of Airframe Structural Components—*H. W. Foster, Lockheed Aircraft Corp.*

A Quarter Century of Propulsion Shafting Design Practice and Operating Experience in the U. S. Navy—*Rudolph Michel, Bureau of Ships.*

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AN OUTSTANDING Symposium on Nondestructive Tests Developed in the Field of Nuclear Energy, sponsored jointly by five societies, will be held at the Hotel Morrison in Chicago, April 16 to 18. Most of these important papers have been recently declassified by the Atomic Energy Commission. One of the main purposes of this symposium is to make available the important information and data to American industry and to all concerned.

A feature of the program, which is detailed here, will be two evening discussion sessions. Prepared questions will be submitted to a panel of experts which will include the authors and speakers of that day. No discussion will be presented during the morning and afternoon technical sessions but will be concentrated in the evening. Written questions may be submitted and will be answered insofar as possible.

Two buffet suppers are planned, preceded by social hours. Brief programs of entertainment for these events are being arranged by the Chicago chapters of the cooperating societies.

All papers in the three-day symposium, together with the four surveys and lectures featuring the opening session and evening discussions are to be published under the sponsorship of the joint cooperating societies.

Opportunity is being given all members of the cooperating bodies to register in advance and to obtain reservation forms for the Hotel Morrison. All interested can secure any of these advance forms from the headquarters of any of the cooperating groups. The forms will also cover reservations for supper and for ordering copies of the final publication at a reduced price.

An executive committee of representatives of the sponsoring organizations has been directing the development of the symposium plans. Warren J. McGonnagle, Argonne National Laboratory, has sparkplugged the entire effort and serves as chairman of the executive committee. The final program will list the committee personnel and the subcommittees responsible for features of the meeting. Following are titles, authors, and abstracts of the papers:

SESSION I TUESDAY, APRIL 16 9:30 a.m.

Survey and Educational Lectures

Nondestructive Testing in the Nuclear Energy Field, Stuart McLain, Argonne National Laboratory

Survey of Eddy Current Methods and Techniques, H. L. Libby, Hanford Atomic Products Operation

Survey of Ultrasonic Methods and Techniques, S. A. Wenk, University of California, Livermore Lab.

Survey of Radiation Techniques, G. H. Tenney, Los Alamos Scientific Laboratory

SESSION II TUESDAY, APRIL 16 2:00 p.m.

As Applied to Components (Part 1)

Production Inspection of Pipe and Tubing by the Immersed Ultra Sound Method. P. B. Oliver, R. W. McClung and J. K. White, Oak Ridge National Laboratory

The inspection procedure presented applies to tubing larger than $\frac{3}{16}$ in. OD and for all pipe sizes up to 8 in. schedule 80 IPS. Rotational speeds up to 300 rpm and linear scanning speeds up to 12 ft per min are employed. The selection of instruments is discussed and the design of mechanical scanning equipment is described. Data presentation methods, gated flaw alarms and the "B" scan instrument are discussed and the merits and limitations of each method. Selection of piezoelectric transducers and the collimation methods for the control of the ultrasound beam are discussed. The necessity of a reference notch on the inner surface of the tubular shape is established. This notch assures the detection of inside defects, assists in the estimation of the defect size and helps minimize the surface-wave indications from shallow scratches on the outer surface. In conclusion, the minimum detectable defect size is defined along with a statement of the confidence level. The results of the inspection experience are summarized and the future development efforts are outlined.

Eddy Current Testing of Capillary Tubing. W. R. Plant and C. Mannal, Knolls Atomic Power Laboratory.

An extremely sensitive eddy-current test for stainless steel capillary tubing is described. Design, construction details, and operation of the electronic equipment are presented, and a cheap and simple search coil is described. The tester consists of an exciting oscillator, a comparison oscillator, a mixer stage and a frequency demodulator. Defect signals may be indicated or recorded. Typical defects and associated chart records are illustrated.

Inspection of Small Diameter Tubing by Eddy Current Methods. J. W. Allen and R. B. Oliver, Oak Ridge National Laboratory.

The basic principles of eddy-current testing are discussed as they apply to the problem of inspecting small diameter tubing. Both encircling coils and probe coils are considered and the relative advantages of each presented. The inspection problem is described in terms of separation and classification of defect types rather than in terms of mere sensitivity to defects. As a possible means of defining defect types, the "impedance analysis" concept introduced by Forster is examined in detail, and it is shown that although this method holds great potential for future development, commercially available instrumentation is not sufficient to allow satisfactory utilization of the approach. The use of an encircling coil type of instrument, of which the commercially marketed Cyclograph is representative, is discussed with regard to its property of variable frequency, and curves relating its parameters of operation are presented. The usefulness of this type of instrument is illustrated with the inspection results of several thousand feet of small diameter tubing. A newly developed instrument, similar in operating principle to the Cyclograph type instrument, but which allows the "impedance analysis" concept to be utilized, is presented and its salient features discussed. General statements are made as to what can be accomplished with an eddy current test on small diameter tubing at present, and what may be expected in the future.

A Nondestructive Test for Intergranular Corrosion in Stainless Steel. R. C. Robinson, Savannah River Laboratory.

An eddy-current instrument is described which indicates the relative degree of intergranular corrosion present in austenitic, stainless-steel tubes. The instrument is applicable to the testing of installed tubing. One per cent differences in resistivity are detected between sample tubes and standard tubes of stainless steel. The instrument possesses good stability and measurements can be made at a fairly rapid rate.

Two Applications of Eddy-Current Instruments to the Testing of Zircaloy Core Components. R. A. Betz, Westinghouse Atomic Power Division.

The application of single frequency and multiple frequency Probolog equipment with an internal probe coil to the inspection of small diameter Zircaloy tubing is discussed. The optimum choice of phase angles and frequencies for the detection of cracks, laps, gauges, tears, and abrupt dimensional changes, the effect of defect size, shape, and orientation on the magnitude of the indication and some correlations between the size of indications and tube burst strength are given. Limitations of the method are considered. The use of a Magnatest type instrument with a probe coil for the determination of edge weld penetration in plate type subassemblies (PWR Seed) is discussed. Maximum effective depth of unweld detection and the effect of test frequency on this depth are discussed. A continuous scanning method and a workable probe holder are given. A calibration standard and method of calibration are discussed.

Inspection of Small Diameter Tubing Using Penetrants. R. B. Oliver and A. Taboada, Oak Ridge National Laboratory.

The fundamentals of penetrant inspection are reviewed and the types of penetrant systems classified. The unique problems of the penetrant inspection of tubing is also discussed. The necessity of careful cleaning prior to the application of the penetrant and the possible effects of prior surface treatment are stressed. The use of a solvent cleaning contrast penetrant is discussed and the procedure for the use of this technique is presented in detail. The use of the post-emulsification cleaning type of fluorescent penetrant for the inspection of tubing in large quantities is also presented. The two penetrant techniques are compared as to their ability to detect the several types of defects that can be revealed by a penetrant inspection. In review, the role played by penetrant inspection is integrated into the program of inspection of small diameter tubing at the Oak Ridge National Laboratory.

SESSION III WEDNESDAY, APRIL 17 9:30 a.m.

As Applied to Components (Part 2)

An Approach to Versatility in Eddy-Current Testing. P. D. Edwards, Los Alamos Scientific Laboratory.

An eddy-current test bench composed of basic electronic circuits is described. By interconnection of these circuits and construction of suitable probes, such a bench can perform a variety of electromagnetic tests, can cover a rather wide band of frequencies; and is therefore, especially useful for custom nondestructive testing as well as for the development of production line instrumentation. Specific applications of this bench to various plating problems, to graphite studies, and to instrument development programs are described; the probes developed for each application are depicted; and the resultant accuracy of the various measurements is given.

Radiography of Materials Used in the Nuclear Energy Field. J. W. Dutli and D. E. Grimm, Los Alamos Scientific Laboratory.

The fundamental techniques employed for radiographing materials used in nuclear energy installations are described. The X- and gamma-ray energies required for radiographing a variety of materials from plastics to gold for thicknesses ranging from foils to several inches are discussed. The X-ray energies range from 5 pkv to 22 Mev; the gamma sources include cesium-137 and cobalt-60. Exposure data for plastic, graphite, beryllium, zirconium, lead, thorium, tantalum, tungsten alloy, uranium, plutonium, and gold are given. Information on film-screen combinations, on radiographic sensitivities and resolutions, and on filter protection against the autoradiographic effects is included. Some practical applications of radiography to reactor component inspections are shown.

The Measurement of Density of Uranium Metal by Radiation Absorption. J. P. Scheuer and P. R. Morris, National Lead Company of Ohio.

Laboratory tests involving use of the Ohmart Density Gauge for the measurement of the density of uranium fuel elements are described. The precision of experimental results is compared to that obtained by hydrostatic methods. The effect of diameter sensitivity on density determination is described and principal sources of instrument drift are considered.

Ultrasonic Testing—Determining Variables in the Processing of Zircaloy and Hafnium Components. E. W. Fink, Westinghouse Atomic Power Division.

A brief introduction to the sonic properties of Zircaloy and hafnium is presented. Typical flow charts for fabrication methods, accompanied by a description of the ultrasonic tests used to determine material integrity at various stages in the processing, are given. The major flaws tested for are described and the test techniques outlined. The problem of writing test specifications is included and the value of such a testing program to the process engineer and Quality Control Section as well as to material conservation is discussed.

Minimizing the Effect of the Probe-to-Metal Spacing in Eddy-Current Testing. C. J. Renken, Jr. and D. L. Waidelich, Argonne National Laboratory.

For the testing of a moving plate of metal it is convenient to have the probe spaced a small distance from the metal surface. Since this distance will vary somewhat as the plate moves, measures must be taken to minimize the effect of this variation on the quantity to be measured which in this case is the thickness of the clad metal on a base metal. It was found that an electronic circuit could be constructed to compensate almost entirely over certain ranges of distance for the variation of phase angle caused by the change in probe-to-metal spacing.

Measurement of Fuel Element Cladding with Eddy Currents. R. B. Oliver, Oak Ridge National Laboratory.

SESSION IV WEDNESDAY, APRIL 17 2:00 p.m.

As Applied to Completed Fuel Assemblies (Part 2)

Nickel-Thickness Gage. L. H. Cook, Savannah River Laboratory.

An instrument utilizing magnetic reluctance techniques was developed to determine the thickness of electrodeposited nickel on uranium. The instrument is simple and maintenance-free in that no vacuum tubes are used. The instrument is useful for measuring nickel thickness in the range of 0.0001 to 0.001 in.

A Precision Density-Thickness Radiation Gage. G. M. Taylor, Los Alamos Scientific Laboratory.

A system is described which is sufficiently stable to resolve changes in a gamma radiation level of 0.03 per cent. The application of the system to the following types of measurement is discussed: density or thickness of uranium, steel, and aluminum; density of foamed plastic; metal concentration in graphite; and the precise location of heavy metal sections encased in a lighter metal. Experimental data are presented on the resolution of the system for each of these problems, and the experimental procedures used are discussed. Requirements for the collimation system, source, size, detector efficiency, time of measurement, source characteristics, and stability of the signal system are presented.

Ultrasonic Transmission Techniques for the Detection of Unbonded Areas in Fuel Elements. J. D. Ross and R. W. Leep, Savannah River Laboratory.

A simplified ultrasonic instrument that utilizes barium titanate transducers, was developed to detect unbonded areas between the cladding and the core of fuel elements. The instrument is stable and requires little maintenance since no high-voltage pulser or high-gain amplifier is required. The output signal of the instrument is used with an appropriate readout system to give either a map record of the unbonded area or a digital reading proportional to the area. Applications of the instrument to specific fuel elements are given.

An Ultrasonic Scanning and Recording System. W. N. Beck, Argonne National Laboratory.

A scanning and recording system for ultrasonic testing using the through transmission technique has been developed. The two transducers and the sample to be inspected are immersed in a water couplant. The two transducers can move laterally and vertically, the two motions being independent of each other. An electrosensitive paper recorder is used in conjunction with the ultrasonic equipment to make a permanent two-dimensional record of the ultrasonic transmission through the sample. The degree of darkening of the electrosensitive paper is determined by the ultrasonic transmission through the sample.

SYMPOSIUM FEES

DAILY REGISTRATION	$5.00
THREE-DAY REGISTRATION	$10.00
SUPPERS	$6.00 each
COCKTAILS	(Dutch)
ADVANCE COPY SYMPOSIUM BOOK* (estimated pages, 300–500)	$7.50

* Symposium Book available late Fall 1957.

Ultrasonic Bond Test. D. C. Worlton, Atomic Power Equipment Dept., General Electric Co.

An ultrasonic method of detecting unbonded areas at the interface between a metal and a thin dissimilar covering metal is described. Twenty megacycle ultrasonic pulses impinging on the surface of the test piece through a liquid bath drive the covering metal into resonant vibrations at those areas directly over an unbonded defect. The "ringing" metal re-transmits ultrasonic vibrations to the transducer and reveals the presence of the flaw. If the covering metal is properly bonded, however, it cannot vibrate and no re-transmitted waves appear at the transducer. This action is discussed in terms of the covering metal functioning as an acoustic transmission line that transfers energy from the liquid medium to the metal to which it is bonded. An instrument developed to apply this principle to routine testing is described. Circuits are explained which obtain a dimensional measurement of flaw size, so that pieces can be segregated on the basis of unbonded area magnitude.

Eddy-Current Techniques for Testing Liquid Metal Bonding. C. J. Renken, Jr. and W. J. McGonnagle, Argonne National Laboratory.

Eddy-current techniques have been used to find lack of bonding in fuel elements using Na bonding. Good correlation has been found between the eddy-current results and the destructive tests. Projected work toward the improvement for this inspection method is outlined.

Electrode Potential Method of Bond Testing. W. G. Marburger, J. H. Monaweck, and W. J. McGonnagle, Argonne National Laboratory.

The electrical resistivity in the immediate neighborhood of a flaw or nonbond differs from that in the solid material. A technique has been developed which uses a change in potential difference as an indication of a flaw. Special electrodes have been made which reduce the effect of surface contact resistance to a minimum. This technique can be used for both flat and round fuel elements.

SESSION V THURSDAY APRIL 18 9:30 a.m.

Measurement of Coating Thickness Using Eddy Currents. C. J. Renken, Jr., Argonne National Laboratory.

An alternating-current probe coil when brought near a metallic surface has its resistance and inductance changed in a manner depending upon the composition and shape of the metal and the spacing between the metal and the probe coil. The change in resistance and inductance may be converted into a change in the amplitude and phase angle of an electrical voltage by means of a bridge circuit. Thickness of the coating may be determined from either amplitude or phase angle measurements although it was found that the phase angle measurements were more convenient. Also measurements of the phase angle made it possible to overcome the effects of probe coil to metal spacing.

Measurement of the Cladding Thickness on Uranium Fuel by Autoradiation. G. E. Bradley, W. J. McGonnagle and P. R. Gonzales, Argonne National Laboratory.

The attenuation of the radioactivity of the uranium core by the cladding was found to be a satisfactory basis for a cladding thickness tester. The attenuation, as determined with beta-sensitive scintillation counter and scaler, or count rate meter, is almost a linear function of the cladding thickness. Aluminum, zirconium, and stainless steel cladding can be measured by this technique.

The Radiographic Inspection of Nuclear Core Materials and Components. A. F. Oaks, Westinghouse Atomic Power Division.

The necessity of developing highly sensitive radiographic procedures for the routine inspection of zirconium, hafnium, and uranium alloy nuclear core components and fuel elements is reviewed. Problems encountered in the development of these procedures and methods used at Bettis Plant to overcome them such as shape correction forms, measuring jigs, two film techniques, etc., are discussed. The utility of different types of radiographic equipment is discussed in terms of the requirements for the different attributes under inspection. Exposure curves are given for zirconium, hafnium, and uranium alloys in the range of 50 to 1000 kvp as well as correction factors for different types of thicknesses of filters. Conversion factors relating these alloys to equivalent thicknesses of steel are also given.

Techniques for X-ray Examination of End Weld Closures of Cylindrical Fuel Elements. S. S. Sidhu, Argonne National Laboratory.

An X-ray technique for locating porosity, cracks, lack of fusion, voids, and inclusions in the closure welds of cylindrical fuel elements will be discussed. Typical results will be presented.

Helium Leak Detection Techniques. W. H. Pappin, Knolls Atomic Power Laboratory.

This paper will present helium mass spectrometer leak detection from an operational perspective. Many of the techniques developed in the fabrication of reactors will be discussed. A method of testing for leaks at elevated temperatures will also be presented and a unique test, "accumulation," will be discussed. Schematic diagrams of testing processes will be shown as well as actual photographs of tests as they are being performed. Some large and small systems will be shown to illustrate the versatility of the test.

Nickel Depth Meter. H. L. Libby, Hanford Atomic Products Operation.

SESSION VI THURSDAY APRIL 18 2:00 p.m.

Miscellaneous Methods and Techniques

An X-ray Flicker Photometer. W. R. Plant, Knolls Atomic Power Laboratory.

Development construction details and operations of a double-beam flicker photometer for nondestructive determination of fuel distribution and total fuel content of fuel elements is described. The single-source, double-beam, single-receiver instrument compares the sample absorption with a wedge standard which is self balanced by a servo system during scanning of the sample. An integrating circuit totalizes the fuel content. Uncertainty of determination is approximately 1 per cent. The principle shows promise of value as an automatic flaw detector for certain applications.

Two Methods for Measuring Total Uranium Content in Co-extruded Al-U_3O_8 Reactor Fuel Plates. G. E. Bradley, Argonne National Laboratory.

Two methods of measuring total uranium content in the Argonaut type reactor fuel elements by transmission of the gamma radiation from Tm-170 have been devised. In both methods it is necessary to measure the areal density of the core and the width of core independently. Method 1 involves the transverse scanning of the plate with a narrow X-ray beam and a Cd-S detector. Resolution in the scanning direction was $\frac{1}{32}$-in. The second method involves measurement of the total radiation transmitted through the plate, as detected by a large plastic phosphor coupled to a 6292 phototube.

A Nondestructive Method for Fuel Assaying. S. G. Forbes, C. H. Hogg, and E. H. Turk, Phillips Petroleum Co.

Since an accurate determination of the fuel content of the MTR fuel assemblies is of considerable importance for both accountability and safety reasons, a low-cost facility for the nondestructive assay of fuel assemblies has been developed at the MTR. The method consists of measurements of fission rate and thermal neutron transmission for a fuel assembly placed in a thermal neutron beam. A measure of the fission rate is obtained by counting moderated fission neutrons that have been intercepted by a cadmium-lined, paraffin-filled box containing BF_3 counters. The transmission is a measure of the total cross-section of fuel plus poison. The complications of an absolute calibration are avoided by comparing the fission neutron response for the "unknown" assembly to that of a standard of known fuel content. If the subscript s designates quantities associated with measurements on a standard homogeneous fuel element of fuel content, U_s, the fuel content, U, of an unknown homogeneous fuel assembly is expressed by

$$U = U_s(R/R)_s \cdot G/G$$

where R is the response of the moderated fission neutron detectors, $G = \frac{1-n/1T}{1-T}$ and T is the transmission statistical data on 122 fuel assemblies shows a standard deviation of about 1 per cent per assembly and an accumulated error in total fuel content of about $\frac{1}{2}$ per cent.

Since the ETR fuel element will contain 2 g of boron, it is hoped that an adaption of this method can be used to assay for both U-235 and boron.

A Technique for Gamma Radiographic Inspection of Parallel Plate Fuel Assemblies. G. D. Calkins, M. Podereskin, R. B. Price, and N. M. Ewbank, Jr., Battelle Memorial Institute.

Using 0.005-in. diam tungsten wire, a line radiation source of tungsten-185 was prepared by neutron activation. Parallel wires, mounted in a holder which fits into the coolant channel, were used to locate the core alloy edge, and necking, and defects in the core for two adjacent fuel plates. From the radiation energy viewpoint, thulium-170 is a more suitable radiation source. Thulium is not available, however, as wire, and a development program for the production of uniform diameter thulium wire would be necessary.

A Panoramic Camera for Inspecting the Walls of Deep Narrow Slots. G. G. Cocks and C. M. Schwartz, Battelle Memorial Institute.

A camera capable of photographing the walls of deep slots has been developed. This instrument was designed to inspect the walls of channels 0.050 by 3 in. in cross-sectional area 30 in. deep. A probe mirror which can be inserted into the slot is fixed in the object plane of the camera lens. The face of the mirror is set at 45 deg to the optic axis of the camera. Rays of light from a point on the wall of the slot strike the mirror and are reflected along the slot through the camera lens and a field-limiting slit and come to a focus on the film. The specimen is mounted on a carriage and moves past the probe mirror. Directly coupled to the specimen trans-

port is a film transport mechanism so arranged that, as the specimen moves past the mirror probe, an image of the wall of the slot is formed on the film. The wall of the slot is illuminated by means of a beam splitter placed in front of the camera lens.

Papers to Be Read by Title Only

(to be included in final publication)

Thermal Testing of Reactor Fuel Elements. J. H. Monaweck and W. J. McGonnagle, Argonne National Laboratory

Helium Leak Detector Test for Nuclear Reactor Closure Welds. A. H. Barnes, F. A. Smith, and E. A. Wimunc, Argonne National Laboratory

A Bond Inspection Method. C. V. Weaver, W. H. Goldthwaite, and R. W. Dayton, Battelle Memorial Institute

Eddy Current Thickness Gauge. H. L. Libby, Hanford Atomic Products Operation

Approximate Determination of Enrichment Factor in Reactor Fuel Plates by Means of Gamma Ray Spectrographic Analysis. G. E. Bradley, Argonne National Laboratory

The Reduction of the Spacing Effect in Pulsed Eddy-Current Testing. D. L. Waidelich, Argonne National Laboratory

Radiography with Thulium Sources. S. S. Sidhu, F. P. Campos, and D. D. Zauberis, Argonne National Laboratory

Microradiography with Reflected Photoelectrons. R. B. Oliver, Oak Ridge National Laboratory

Settling Rates of Slurries Using Radiography. R. B. Oliver, Oak Ridge National Laboratory

Testing of Cylindrical Fuel Elements using the Cyclograph. W. J. McGonnagle, Argonne National Laboratory

ASTM STANDARDS APPROVED AS AMERICAN STANDARD BY AMERICAN STANDARDS ASSN

CAST IRON (Approved December 26, 1956)

Spec. for Gray Iron Castings (ASTM A 48-56; ASA G25.1-1956)

PETROLEUM PRODUCTS AND LUBRICANTS (Approved December 18, 1956)

Method of Test for Flash Point by Tag Closed Tester (ASTM D 56 – 56; ASA Z11.24-1956)

Method of Test for Distillation of Gasoline, Naphtha, Kerosine, and Similar Petroleum Products (ASTM D 86 – 56; ASA Z11.10-1956)

Method of Test for Saybolt Viscosity (ASTM D 88 – 56; ASA Z11.2-1956)

Method of Test for Flash and Fire Points by Cleveland Open Cup (ASTM D 92 – 56; ASA Z11.6-1956)

Method of Test for Saponification Number of Petroleum Products by Color—Indicator Titration (ASTM D 94 – 56 T; ASA Z11.20-1956)

Method of Test for Water in Petroleum Products and Other Bituminous Materials (ASTM D 95 – 56 T; ASA Z11.9-1956)

Method of Test for Copper Corrosion by Petroleum Products (Copper Strip Test) (ASTM D 130 – 56; ASA Z11.21-1956)

Method of Test for Vapor Pressure of Petroleum Products (Reid Method) (ASTM D 323 – 56; ASA Z11.44-1956)

Method of Test for Knock Characteristics of Motor Fuels by the Motor Method (ASTM D 357 – 56; ASA Z11.37-1956)

Method of Test for Oil Content of Petroleum Waxes (ASTM D 721 – 56 T; ASA Z11.52-1956)

Method of Test for Knock Characteristics of Motor Fuels by the Research Method (ASTM D 908 – 56; ASA Z11.69-1956)

Method of Test for Evaporation Loss of Lubricating Greases and Oils (ASTM D 972 – 56; ASA Z11.93-1956)

Method of Test for Olefinic Plus Aromatic Hydrocarbons in Petroleum Distillates (ASTM D 1019 – 56 T; ASA Z11.71-1956)

ASTM-IP Petroleum Measurement Tables (ASTM D 1250 – 56; ASA Z11.83-1956)

GYPSUM (Approved January 15, 1957)

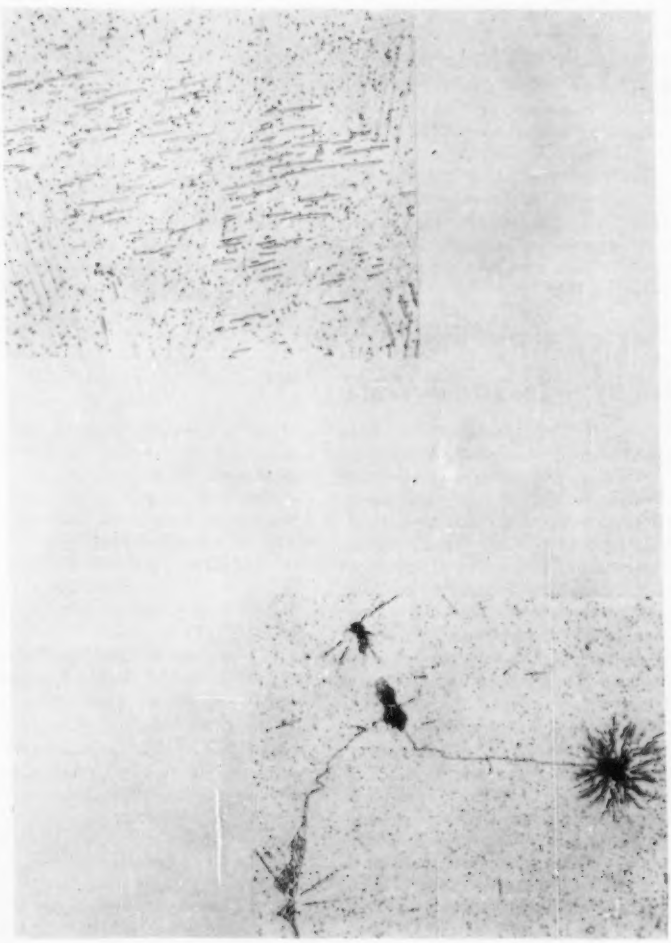
Methods of Testing Gypsum and Gypsum Products (ASTM C 26 – 56; ASA A70.1-1957)

Radioactive Tracer Techniques

Second Prize, Special Techniques—Tenth ASTM Photographic Exhibit. J. Boyd, W. Couts, J. Gates, and G. Wheeler, Battelle Memorial Institute, Columbus, Ohio.

Top: Ti-3Mn complex with 600 ppm H_2 including H_3 Etchant: 1.5 per cent HF, 3.5 per cent HNO_3, 95 per cent H_2O Magnification: × 1500 (Reduced for publication)

Bottom: As-cast stainless steel with Mischmetal and radioactive lead additions. Etchant: Marble's reagent. Magnification: × 1125 (Reduced for publication)



Radiation from the tracer element exposes an emulsion affixed to the specimen. After development, silver grains in the emulsion reveal the location of the tracer element.

The top picture confirms the preferences of hydrogen to dissolve in beta titanium. Highly energetic alpha particles expose chains of silver grains in the bottom photomicrograph.

NEW ASTM PUBLICATIONS

Symposium on Corona

THE DELETERIOUS effects of corona on organic electrical insulation have been known for years, and considerable research and investigational work has been carried out by manufacturers and users of organic materials to evaluate their stability in applications where operating voltage gradients approach ionizing levels. Work in this field has been largely of an independent nature, each manufacturer and user of insulating materials approaching the problem from his own point of view. The result has been that no common or standard methods of corona detection and evaluation of the corona resistance of insulating materials have appeared in the literature.

Recognizing the need for standardizing methods of corona detection and material evaluation, Section L was set up under Subcommittee XII on Electrical Tests of ASTM Committee D-9 on Electrical Insulating Materials, to undertake work in that direction.

One of the first steps in this program was to organize a symposium on this subject, which was held in November 1955 during the Committee D-9 meeting in Cincinnati, Ohio. Its general purpose was to give members of Section L an opportunity to present their present test methods and results and to inform those interested in this subject of the complexities involved.

Titles and authors of the papers that appear in the Symposium are as follows:

Introduction—*E. B. Curdts*
Preliminary Corona Resistance Test Results from IEC Activities—*C. W. Ross*
Effects of Corona on Thermosetting Plastic Laminates—*A. Rufolo and R. R. Winans*
Corona Resistance Test Method for Laminates, Molded and Cast Materials—*W. T. Starr*
Preliminary Investigation of Proposed Pulse Method for Measuring Ionization—*F. S. Oliver, T. A. Pinkham, and E. H. Povey*
Corona Detection and Measurement at Sixty Cycles—*J. R. Nye*
Test Method for Measuring Energy in Gas Discharge—*S. I. Reynolds*

Copies of this symposium, *STP No. 198*, can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price: $1.25, to members $1.

Manual on Industrial Water

THIS third printing of the Manual offers a broad discussion on the nature and uses of industrial water, plus up-to-date testing methods and specifications developed by leading authorities in the field. While the discussion, comprising the first eight chapters, is essentially the same as the first printing, 20 new methods of testing, many revisions of existing methods, a complete table of contents, and a detailed index have been incorporated in the new edition.

Demand for the first printing was so great that the Society's stock was completely exhausted in a short time. In order to meet this constant demand, it has been necessary to publish a second printing and now a third, since a complete new edition, now under study, is still some distance in the future.

This Manual is intended as a brief reference source of information for three types of users: executives and plant designers; individuals engaged in industrial operations involving the use of water; and analysts, operators of special instruments, engineers, and consultants. It provides basic information for routine use and gives direction into the technical literature, thus serving as a point of departure for more specific and detailed studies.

For executives, plant managers, designers, and similar technologists and administrators it offers information on the influence of water on industries in which it is used either as a raw material or in conjunction with manufacturing processes. The Manual should serve as a guide to the nature of water planning required at the supervisory and investment levels. Operating personnel, chemists, and other technologists can use the Manual as a reference for specific information unassembled elsewhere.

The eight chapters cover: (1) Uses of Industrial Water; (2) Difficulties Caused by Water in Industry; (3) Composition of Industrial Water and Water-Formed Deposits; (4) Treatment of Industrial Water; (5) Sampling of Industrial Water; (6) Analysis of Industrial Water; (7) Sampling and Identification of Water-Formed Deposits; and (8) Analysis of Water-Formed Deposits.

The 55 standards include definitions, sampling methods, analytical methods, corrosivity tests, methods of reporting, and general testing methods. Added for information are a proposed method on appearance properties and five proposed methods for analysis in the evaporative industry.

This 504-page manual, *ASTM Special Technical Publication No. 148-B*, can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price: $6; to members, $4.50.

ASTM Standards on Textile Materials

THE LATEST ASTM tentative and standard methods of tests, specifications, and definitions pertaining to textile materials are included in this book prepared by ASTM Committee D-13 on Textile Materials. Of the 126 standards and tentatives, 21 are new and 8 were revised since the previous edition of the book was published in January, 1956. Fourteen appendices cover 13 proposed recommended practices, methods of test and specifications, as well as a table of the Basic Properties of Textile Fibers, Psychrometric Table for Relative Humidity, and the Yarn Number Conversion Table.

The compilation also contains the report of Committee D-13, regulations governing the committee, the names and addresses of committee officers, and the personnel of the committee. There is an extensive index.

The standards cover terms and definitions; testing machines; humidity testing; interlaboratory testing; identification for qualitative analysis; quantitative analysis; resistance to insect pests and microorganisms; fibers; yarns, threads, and cordage; fabrics; hosiery; asbestos textiles; bast and leaf fiber textiles; cotton textiles; glass textiles; rayon, acetate and silk textiles; warp knit fabrics; wool textiles; pile fabrics; and nonwoven fabrics.

Copies of this 836-page compilation may be obtained from the American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., at $6.25 per copy: to members, $4.70.

ASTM Standards on Plastics

IN THE seventh edition of this compilation appear in their latest revised form some 150 specifications and methods of test developed by ASTM Committee D-20 on Plastics. It also includes certain selected standards prepared by other ASTM technical committees which are applicable to the plastics industry.

The standards cover plates, sheets, tubes, rods, and molded materials; mechanical, thermal, optical, and permanence properties of plastics. In addition, analytical methods, molding processes, nomenclature and conditioning; and numerous electrical tests pertaining to plastics.

New items include specifications on molding and extrusion materials, namely, polychlorotrifluoroethylene, styrene, acrylonitrile, polyvinyl chloride, and tetrafluoroethylene. An appendix contains, as information only, a proposed Method of Test for Environmental Stress Cracking of Ethylene Plastics.

Copies of this 864-page compilation can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price: $6; to members, $4.50.

Five-Year Index to ASTM Publications

THE Five-Year author and subject Index to papers published in the years 1951 through 1955 supplements and brings up to date the Fifty-Year Index which covers the period from 1898 through 1950.

Representing, in the main, a compilation of indexes from the yearly *Proceedings*, the Index covers technical papers which have appeared in the *Proceedings*, the ASTM BULLETIN, *Special Technical Publications*, or in special compilations of standards.

In addition, it also shows a listing of *all* ASTM STP's and a topical listing of all symposia that have been held under Society auspices. The index to individual standards published in the triennial Book of ASTM Standards is not included in the 50-year or 5-year Indexes. These indexes are published separately each year.

This 5-Year Index together with the 50-Year Index volume, will provide the librarian, the researcher, and the technologist with a key to all ASTM technical papers through 1955. These, together with the indexes to each annual *Proceedings* volume, which members receive on their membership, when requested, will provide a continuing up-to-date ASTM Index until publication of the next Index at the five-year interval.

Copies of the Index can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. Price: $3.50; to members, $2.65.

Mass Spectrometry Committee Schedules Meetings and Papers Sessions

ASTM Committee E-14 is holding meetings and papers sessions on all phases of mass spectrometry at the Commodore Hotel in New York City from May 20 to 24. Special half-day discussion sessions have been scheduled for Subcommittee VII on Solids Techniques and for Subcommittee V on New Instruments and Techniques.

Requests for more detailed information on the program should be addressed to the secretary of the committee, Fred W. McLafferty, Dow Chemical Co., Framingham, Mass.

ISCC Meets in March

THE program of the 26th Annual Meeting of the Inter-Society Color Council, to be held at the Hotel Statler in New York City on Mar. 5–6, 1957, will emphasize the importance of analysis of styling and color trends to production planning and sales promotion of colored commodities.

The Inter-Society Color Council is composed of delegates from 26 national trade or technical organizations (of which ASTM is one) and individual members interested in problems related to color. The aims and purposes of the ISCC are: "To stimulate and coordinate the work being done by various societies, organizations, and associations, leading to the standardization, description, and specification of color, and to promote the practical application of these results to the color problems arising in science, art, and industry."

This meeting immediately precedes the Winter Meeting of the Optical Society of America to be held at the same location March 7–9. OSA papers relating to the broad subject of color will be scheduled for March 7 for the convenience of ISCC members and guests.

Free Exchange of Nuclear Information Fostered by Conference

150 Papers in Second Nuclear and Engineering Science Conference

THE AMERICAN SOCIETY FOR TESTING MATERIALS has joined with about 20 of the nation's technical and scientific societies in sponsoring the Second Nuclear and Engineering Science Conference to be held Mar. 11–14, 1957, at Convention Hall in Philadelphia. The Conference is part of the 1957 Nuclear Congress which will also include the Fifth Atomic Energy in Industry Conference, the Fifth Hot Laboratories and Equipment Conference, and the Third International Atomic Exposition.

More than 150 technical papers by some of the nation's leading nuclear engineers and scientists will be presented at 32 technical sessions covering such topics as:

- Reactor Design
- Reactor Components
- Waste Disposal
- Metallurgy
- Thermodynamics
- Fuel Production and Processing
- Reactor Control and Instrumentation
- Reactor Operation and Maintenance
- Protection of Water Supplies
- Natural Resources
- Radiation Protection —Limits and Codes
- High Intensity Radiation Processing
- Fusion
- Coolant Systems
- Shielding and Construction
- Use of Educational Nuclear Reactors
- Standardization
- Safety

The Congress has been organized to foster a free exchange of knowledge, information and ideas between engineers and scientists in all fields of technology and among leaders in industry and management, and to bring into one meeting the latest information and exhibits from these fields covering creation and utilization of atomic energy for peaceful purposes.

Advance programs, information on how to register in advance, and hotel reservations are available and may be obtained by writing to the Engineers Joint Council, 29 W. 39th St., New York 18, N. Y., which is coordinating the Congress, or to ASTM Headquarters.

ASTM Bulletin

FEBRUARY 1957

NO. 220

NINETEEN-SIXTEEN
RACE STREET
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ASTM and the Aircraft Industry

WHILE some of the aircraft materials problems may be approached using more or less conventional techniques such as those described in existing ASTM test methods, it should be recognized that there are a great many problems that are unique to the application of the materials in aircraft and require new techniques. High strength-weight ratios are a must, and a continuing search is revealing new materials and materials combinations such as sandwich structures which provide such properties. Flight at high altitudes imposes special requirements on electrical systems where the reduced pressures lower the voltage at which corona and arcs can start. Vibration and fatigue are special problems in aircraft, especially since failures may be catastrophic. At very high speeds, aerodynamic heating becomes a serious problem and it is necessary to devise entirely new and novel test equipment to study the properties of materials and structures under such conditions. There are also special problems involved in propulsion units and fuels, especially in some of the newer types of military aircraft in existence or projected.

Challenges to ASTM in this area were outlined quite effectively in Gen. Irvine's address at the West Coast National Meeting,[1] in Rebecca Sparling's paper,[2] and in the feature article on NACA in this issue.

Progress toward solution of aircraft-materials problems may be accelerated by a pooling of effort and exchange of information among those working in this field. Good examples of exchange of information are the Symposiums on Structural Sandwich Construction and on Fatigue presented at the West Coast National Meeting in September and currently being published. Cooperative effort is exemplified by the work of the many ASTM technical committees as well as such important intersociety groups as the Joint ASME-ASTM Committee on the Effect of Temperature on the Properties of Metals.

Considering the great importance of aircraft material problems to the nation's defense and future progress, ASTM committees need constantly to examine their programs to determine whether or not sufficient emphasis is being placed on this important area of materials evaluation.

[1] Lt. Gen. C. S. Irvine, "Super Materials for Super Performance," ASTM BULLETIN No. 218, p. 11, December, 1956.

[2] Rebecca H. Sparling, "Testing in the Guided Missiles Industry," ASTM BULLETIN No. 218, p. 52, December, 1956.

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and location of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups.

Date	Group	Place
March 4	Committee E-13 on Absorption Spectroscopy	Pittsburgh, Pa. (Wm. Penn Hotel)
March 5	Committee E-12 on Appearance	New York, N. Y. (ASA Headquarters)
March 6-7	Committee E-2 on Emission Spectroscopy	Pittsburgh, Pa. (Wm. Penn Hotel)
March 11-12	Committee D-12 on Soaps and Other Detergents	New York, N. Y. (Park Sheraton Hotel)
March 14	New York District	New York, N. Y.
March 19-22	Committee D-13 on Textile Materials	New York, N. Y. (Sheraton-McAlpin Hotel)
March 21	Philadelphia District—Student Night	Bethlehem, Pa. (Lehigh University)
April 9-10	Committee D-10 on Shipping Containers	Chicago, Ill.
April 16	Committee C-18 on Natural Building Stones	Washington, D. C.
April 25-26	Committee D-15 on Engine Antifreezes	Washington, D. C. (Shoreham Hotel)
May 2	Committee C-20 on Acoustical Materials	New York, N. Y. (ASA Headquarters)
May 3	New England District—Kingston, R. I.	
May 20-24	Committee E-14 on Mass Spectrometry	New York, N. Y. (Commodore Hotel)
JUNE. 16-21	**ANNUAL MEETING**	**ATLANTIC CITY, N. J. (CHALFONTE-HADDON HALL)**

General Services Administration and ASTM Sign Contract for ASTM Standards

THE General Services Administration has renewed its contract with ASTM, originally made in January, 1956, to supply a selected list of ASTM standards to Federal Government agencies at special discounts. The new contract covering the period Dec. 1, 1956 through Nov. 30, 1957 lists about 500 separate ASTM methods of test and specifications for materials. A special authorized price list has been published by the Society and distributed to Government agencies through ten GSA Regional Offices.

The Federal Government has actively participated with ASTM in research and development of standard specifications and methods of test for materials for more than 50 years. Many Government departments have contributed to and benefited from the work of the Society through official representation on technical committees. They have also referred drafts of Federal specifications for material to the Society for technical review and comment. In addition many individuals in Government service hold personal membership in ASTM and serve as individuals on committees. This has resulted in an exchange of information and close similarity between many ASTM specifications and methods of test and Federal specifications. Many Federal specifications and test methods include ASTM standards by reference, and this Supply Service Contract has been prepared to facilitate the purchase of these standards.

Interested Government agencies may obtain copies of the authorized price list from the General Services Administration, Federal Supply Service, Regional Offices.

ASTM Finances in 1956

Favorable Year Gives Good Carry-Over for 1957 and 1958

As was hoped for and also expected, the complete financial returns for 1956 (fiscal year ending November 30) show a good favorable balance between income and outgo.

In considering that receipts exceeded disbursements by about $186,000, it must be remembered that we really operate on a three-year period because of the influence of the triennial publication of the Book of Standards. 1956 was the year in this period when receipts could be considerably higher than for the two succeeding years.

The 1957 budget anticipates a deficit of about $74,000, which will mean drawing on surplus. The Board of Directors reviewed the details of operations for the year at its January 15 meeting, and the financial picture will appear as customarily, in the Annual Report of the Board of Directors to the Society at the meeting in Atlantic City the week of June 16.

Income—$1,082,550
(Our best membership year and heavy distribution of books including the big Book of Standards built this up in a gratifying way.)
Spent—$896,500
(Publication and costs continue very heavy, but to achieve our purpose we must publish and disseminate data widely.)
Net—An encouraging favorable balance of $186,000
(This is much better than the budgeted favorable balance of $34,000.)
Total Assets—$1,473,500
(This is up about $129,000. A good income year was the cause.)
Surplus—$444,500
(While this is higher, it still represents only 49.4 per cent of annual disbursements, just less than six months' operations.)

1956 Income

Receipts reached an all-time high of $1,082,600. Our best membership year, in which over 1000 new members were added, helped materially, but the most significant figure was again total sale of publications—$696,000. With improved Bulletin advertising income, and revenue from exhibits, as well as investment income, miscellaneous receipts totaled $117,600.

In noting the trend in recent years whereby publications are gradually providing the larger portion of our income, the Directors recognize that this is not due to a decrease in membership, but rather to wider demands for the information and data given in the standards and our many technical publications. The sale of these books is vital to our operations, but more significant, it results in wider use of the society's standards and publications.

The percentage of income from dues and publications is shown in the accompanying table.

1956 Costs

Costs continue to mount. In 1956, the total was $896,500. Publication costs were $342,300 not including the $85,000 portion of the 1958 Book of Standards reserve.

Publications represented 38.2 per cent of total costs.

In 1956, 34.5 per cent of our disbursements were for salaries, including extra clerical help and overtime. One special item in 1956 was the Second Pacific Area National Meeting which added something over $10,000 to meeting costs. Obviously, as the Society grows, handling a tremendous volume of publications, in addition to steadily expand-

OPERATING RECEIPTS

Source	1956		1955		1954		1953	
		Per cent		Per cent		Per cent		Per cent
Dues	$268 985	25.0	$252 072	29.6	$236 345	29.8	$233 705	28.7
Sales of Publications	695 950	64.0	521 496	61.3	470 459	59.2	512 262	62.9
Miscellaneous								
Advertising	43 324	...	31 994	...	28 214	...	28 398	...
Interest and Dividends	29 798	...	27 162	...	23 754	...	21 956	...
Registration Fees	16 622	...	13 701	...	12 581	...	13 768	...
Exhibit	20 168	...	750	...	16 144	...	1 355	...
Other	7 704	...	4 628	...	7 048	...	3 196	...
Total Miscellaneous	117 617	11.0	78 235	9.1	87 741	11.0	68 673	8.4
Total Receipts	$1 082 552	100.0	$851 803	100.0	$794 546	100.0	$814 640	100.0

OPERATING DISBURSEMENTS

Item	1956		1955		1954		1953	
		Per cent		Per cent		Per cent		Per cent
Publications	$342 323*	38.1	$349 963†	41.2	$277 346	36.9	$263 811	44.9
Salaries	309 402	34.3	305 362	35.8	276 855	36.9	237 761	33.0
General Office Expense	111 557	12.5	83 342	9.8	79 802	10.6	75 773	10.5
Meetings and Technical and District Committees	42 206	4.8	27 121	3.2	33 270	4.4	23 253	3.2
Headquarters Occupancy	35 582	4.0	35 319	4.1	31 035	4.2	21 658	3.0
Retirement, Health	32 603	3.7	32 855	3.9	27 429	3.6	21 070	2.9
Miscellaneous	22 840	2.6	17 390	2.0	25 250	3.4	17 797	2.5
Total Disbursements	$896 513	100.0	$851 352†	100.0	$750 987	100.0	$661 123	100.0

* Does not include $85,000 earmarked as a reserve for the 1958 Book of Standards, and not expended.
† Includes $100,000 earmarked for the 1955 Book of Standards. This, together with $120,000 from the two previous years, earmarked but not spent, really spreads the cost of this Book over a three year period.

1957 BUDGET SUMMARY.

Estimated Receipts

		Per cent
Dues and Entrance Fees	$275 000	28.2
Publications	574 500	62.0
Miscellaneous	93 500	9.8
TOTAL CURRENT RECEIPTS	$943 000	100.0
From Surplus	74 400	
	$1 017 400	

Estimated Disbursements

		Per cent
Publications	$406 500	40.0
Salaries	380 500	37.5
General Office Expenses	93 500	9.2
Technical Committee Expenses	11 800	1.2
Meetings	16 000	1.5
Headquarters Occupancy Expenses	42 500	4.1
Retirement Insurance Expense	44 500	4.3
Miscellaneous Expenses	22 100	2.2
TOTAL OPERATING DISBURSEMENTS	$1 017 400	100.0

ing technical work, its costs will increase. Every effort is made to place our operations on as efficient a basis as possible through mechanization and simplification of records and reports.

Headquarters Building

The general operating funds continue to pay into the building fund a reasonable amount for depreciation and amortization, both considered part of occupancy expenses. Amortization of a loan is based approximately on a seven-year period.

Unquestionably the value of our buildings in Philadelphia is enhanced each year by developments in the general area. Several new buildings have been erected around us, and others are planned.

Assets and Surplus

Total assets reached about $1,474,000, including general and special funds. Because of this good year in our three-year period, about $64,000, was added to surplus, the total surplus now being $444,500; this figure represents 49.4 per cent of our 1956 costs of operations.

Investments

Under the guidance of investment counsel, more of our funds were put to work during the year, especially through the purchase of Government and industrial bonds, including convertibles. The combined Investment Fund has simplified our operations. Income from investments was just over $37,500, of which General Funds received $29,800. This is not earmarked but is used in our over-all operations. The yield on book value is about 5¼ per cent.

1957 Budget

In 1957 we cannot expect nearly so much income from sale of publications as orders naturally fall off for the 1955 Book of Standards. Nevertheless, some of this will be taken up by publication of an increased volume of technical papers including many hundreds of pages from the 1956 West Coast Meeting. The Budget Summary given here shows that income should reach about $943,000, but that $74,400 will be needed from surplus to balance the budget. We remind our members again that 1957 is really the second in a three-year budget period.

The Finance Committee will follow developments very closely and devote its efforts as in the past to keeping our financial operations in step with a rapidly growing organization that is itself endeavoring to keep pace with our expanding economy.

First Standards Engineers Society—ASTM Award Goes to Dickson Reck

A JOINT Standards Engineering Society—ASTM Award has been established to recognize outstanding accomplishments in the field of standardization. The first award was made posthumously to Dickson Reck at a December meeting in New York City attended by SES and ASTM members.

Dr. Reck, holder of a Fellowship on Standards at the University of California, was the author of a recent book on standardization which was felt to be an outstanding accomplishment.

The ASTM is underwriting the modest honorarium and certificate awarded to an individual selected by the SES. A young but healthy and growing organization, the SES includes several hundred technical men who concentrate in the field of standards, many of them being standards engineers with their companies. This group has established sections and holds national meetings.

The SES president is M. S. Gokhale, Corporate Staff, Standardizing, Radio Corporation of America; the vice-president is H. G. Arlt, Technical Staff, Bell Telephone Laboratories, Inc.; the secretary is C. W. Bowler, head, Standards Section, Leeds & Northrup Co.

To ASTM Members: Your help is needed in maintaining that constant increase in ASTM Membership

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To the ASTM Committee on Membership,

1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send information on membership to the company or individual indicated below:

_____

_____

This company or individual is interested in the following subjects: indicate field of activity, that is, petroleum, steels, non-ferrous, etc.

_____

Signed _____

Date _____ **Address** _____

Standards Committee Approves Soil Investigation Method

APPROVAL was given on January 17 by the Administrative Committee on Standards to a new Tentative Method for Soil Investigation and Sampling by Auger Borings (D 1452–56 T). The method was developed and prepared by ASTM Committee D-18 on Soils for Engineering Purposes.

Auger boring is one of the most widely used methods for investigating soils and although the method is fairly simple there has been a need for a standard that outlines the procedure in detail and gives the requirements and limitations. The method may be used for any purpose where disturbed samples can be used and it is valuable in connection with spoon and tube sampling. Equipment required is simple and readily available. Depths of auger investigations are, however, limited by ground-water conditions, soil characteristics, and the equipment used.

1956 Revision for Specifications for Billet Steel Bars for Concrete Reinforcement Published in Error

THROUGH an error in balloting in ASTM Committee A-1 on Steel, a 1956 revision of the Tentative Specifications for Billet Steel Bars for Concrete Reinforcement (ASTM Designation: A 15) has appeared in printed form. This error was not discovered until the early part of December, 1956, after some copies of the Specifications bearing the designation A 15 – 56 T had been distributed.

This revision of the specifications should not be made and the edition in effect is therefore A 15 – 54 T.

William D. Appel to Receive Textile Committee Award

ASTM's Committee D-13 on Textile Materials will present the Harold De Witt Smith Memorial Medal to William D. Appel, chief, Textiles Section, National Bureau of Standards, on Mar. 21, 1957, during the spring meeting of the committee March 19 to 22, in New York City.

The medal is a testimonial to the memory of the late Harold De Witt Smith who pioneered in the concept of an engineering approach to the evaluation of the properties of textile fibers and to their utilization. It was endowed by Fabric Research Laboratories, Inc., Boston, and is awarded at intervals of not less than one year by Committee D-13 for outstanding achievement in research on fibers and their utilization.

Mr. Appel, the eighth recipient, has had a long and distinguished career as scientist and leader of research and of service to the industry through his activities in various scientific and technical associations and societies.

Mr. Appel was graduated from the University of Chicago with honors in 1917 and after several years in industry as a dye chemist, he joined the National Bureau of Standards in 1922.

Under his leadership the work of the Bureau's Textiles Section expanded and new knowledge in the fields of engineering, chemistry, physics, mathematics, statistics, photochemistry, microscopy, spectroscopy, and electronics were applied vigorously on fundamental, applied, and consumer research problems in textiles. He has published over 50 papers and reports, and in addition, over 600 papers and reports have been published by members of his staff.

Mr. Appel has taken a prominent part in the development of standards for test methods and specifications. He served three terms of two years each as Chairman of Committee D-13. In 1948, he was a delegate to the organization meeting of Technical Committee 38 on Textiles of the International Organization for Standardization held at Buxton, England. Also he was a leader of the U.S.A. delegations to the ISO meetings in England in 1951 and 1956.

William D. Appel

He has had many honors. He received the War Department Certification of Appreciation for Patriotic Services during World War II and also the American Standards Association Certificate of Appreciation for services on war standards (World War II). In 1953 he received the Department of Commerce Gold Medal for Exceptional Service, the highest award of the De partment given in recognition for outstanding contribution to public service, the nation, or humanity. In 1954, he was awarded the Olney Medal, highest award of the American Association of Textile Chemists and Colorists.

To ASTM Nonmembers: The Society welcomes inquiries on the "Advantages of Membership"

To the ASTM Committee on Membership
1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on Membership in ASTM and include a membership application blank.

Signed _____

Address _____

Date _____

Technical Committee Notes

Industrial Water

Committee Readies Three New Test Methods

COMMITTEE D-19, at its January meeting in Charleston, S. C., approved three proposed new tentatives for committee letter ballot. They cover methods of test for nitrite by the Rider-Mellon method, for low concentrations of iron by the phenanthroline method, and for appearance properties of industrial water.

Some 20 new and revised methods of testing industrial water and industrial waste water are currently under development. Among the more significant new projects are those on flow measurement, determination of hydrogen, measurement of radioactivity, measurement of surface tension, determination of surface-active materials, determination of biochemical oxygen demand, and performance tests on ion exchange resins for water treatment.

Arrangements were reviewed for the symposium on determination of dissolved oxygen that Committee D-19 plans to sponsor at the 1957 Annual Meeting of the Society. Preliminary plans were initiated for a symposium on examination of industrial water and industrial waste water for radioactivity, preferably to be arranged for the 1958 Annual Meeting of the Society.

Progress reported on the preparation of an extensively revised second edition of the Manual on Industrial Water now indicates that it should be ready for publication early in 1958. For information on the third printing of the first edition of the Manual, see page 10.

Engine Antifreezes

Foaming Properties Measurement Under Study

A SECOND collaborative test on the glassware procedure for foaming properties of engine antifreezes has been undertaken under the auspices of Committee D-15 by five cooperating laboratories testing five types of antifreezes. These antifreezes include: General Services Administration type antifreeze, a "borderline" foaming antifreeze, a two-phase oil type, a single-phase nonoil type, and a single-phase soluble type antifreeze. The apparatus will consist of a glass cylinder containing the antifreeze to be tested and into which an aerator tube carrying metered, clean, dry air is placed. The cylinder and its assembly is placed in a constant temperature bath.

The amount of f[illegible]am will be measured after a 5-min aeration period. The "break time" will also be determined after the removal of the aerator tube.

Shipping Containers

Work on Interior Packing Widens

THE GROWTH of interest in the field of interior packing has enlarged the scope of activities of Subcommittee VI on Interior Packing. At the October meeting of Committee D-10 in St. Louis, Mo., the broad coverage of work of this subcommittee was apparent.

The Task Group on Dusting and Breakdown Under Repeated Impact is presently circularizing a draft method in which a specimen of cushioning material is repeatedly dropped. The loss in weight of the specimen is considered the measure of dusting. A proposal was made that vibration should be considered an integral part of the test.

The Task Group on Resilience presented some research work which has been accomplished in this field. Some doubt was expressed concerning the application of resilience information to packaging, and interested members are being asked to submit comments in order to clarify the scope of work in this category.

The Task Group on Methods of Evaluation for Use of Dunnage considered the possibility of developing methods for evaluating excelsior (wood), shredded paper, cellulose wadding, rubberized fiber, corrugated fiber board, sponge rubber products, and plastic and vinyl materials. This Task Group will approach manufacturers of these types of cushioning or dunnage materials for information and data of important property characteristics which can be evaluated by standardized test procedures.

The Task Group on Compatibility of Packaging Materials reviewed a number of methods currently available to test for staining, corrosion, pressure-marking, tarnish, and abrasion. Comments on the use of the methods to test for these reactions in packaging materials are being solicited from industry as a basis for future work.

Committee Coordinates Cellular Materials Activities

AN EXPERIMENTAL house has been built using polystyrene foam as a major constituent. Cellular materials, both rigid and flexible, are increasingly being used for thermal insulation, cushioning the energy-absorbing applications in packaging, crash pads, automotive and furniture seating, acoustical insulation, dielectric lenses and other electrical applications, toys and novelties, clothing, and many other applications. Materials include foam and sponge rubber as well as such other cellular polymeric materials as polystyrene, polyethylene, polyurethanes, polyvinyl chloride, cellulose acetate, and the phenolics and ureas.

With such a wide variety of materials and applications, it is no wonder that the problems of establishing standards—both test methods and specifications—for these materials are being actively pursued by a number of ASTM committees as well as several trade groups. About two years ago when it was realized that interest in cellular materials existed among a number of ASTM committees, the Society established the Coordinating Committee on Cellular Materials to facilitate exchange of information and to provide a means for the interested groups to get together and resolve any differences that might arise.

At its meeting on January 8, the Coordinating Committee established an operating procedure and outlined the areas of responsibility for each of the interested ASTM committees.

The committee also is arranging for an exchange of information among its members so that duplication of effort may be avoided and so that each technical committee concerned may profit by the findings of the others in the development of standards for cellular materials.

SOUTHWEST DISTRICT

Steel Tubular Products for the Petroleum Industry

On January 21 the Southwest District sponsored jointly with the Texas Chapter of the American Society for Metals a dinner and lecture in Houston. Some 140 men heard C. L. Clark, Steel and Tube Div., Timken Roller Bearing Co., evaluate steel compositions for service at high temperatures and in the oil industry.

Two items of particular interest were brought out: First, that coarse grained steels appeared to have more constant elevated temperature properties than fine grained steels. Thus, if coarse grain practice were standardized it would probably result in the codes permitting higher minimum stress levels for the same steel composition. The second point was that designers would probably be better off to design equipment to operate at temperatures and pressures where the standard austenitic grades of steel could be used, rather than the super-strength alloys which are not readily obtainable and which demand a high price.

P. L. DeVerter, chairman of the Southwest District, conducted the meeting. J. W. Caum, of the Headquarters Staff, discussed some of the outstanding developments in the Society during the past six months. Dr. Clark was introduced by J. J. B. Rutherford, chief metallurgist of the Tubular Products Div., Babcock & Wilcox Co.

ACR Notes

The Missing Link in Research

BY W. H. LUTZ[1]

It is generally conceded that successful research depends upon creative scientific personnel, proper facilities, a good intellectual environment, and appropriate communications. One additional factor is needed, but is seldom mentioned, and that is salesmanship. I have chosen to call this factor the missing link in research.

Many technical men have little interest in salesmanship. A few regard "selling" as professionally undignified. Some associate salesmanship with cigars, stories, and high pressure. The role played by a good salesman does not justify any of these attitudes. A good salesman makes the customer want his product. He employs persuasion, not pressure. He spends much time in preparing his presentation, and he makes every word count. If he does not succeed, the resourceful salesman develops some new line of attack.

Today, all companies are sold on research, but all companies are not necessarily receptive to research results. It is a mistake for research personnel to assume that company management is just waiting to adopt every new development. Businessmen have a healthy and justifiable skepticism of new things—particularly if they do not quite understand the new things. Businessmen know from experience that the adoption of new products and new processes is invariably accompanied by financial problems and production headaches. The research man must, therefore, become a salesman to win acceptance of his development.

How does a research man go about selling his results? First of all, he needs to work out an appropriate presentation. This should be based on simple step-by-step logic. He must select readily understood terms and keep complex technical words to a minimum. Obviously, he will stress the advantages of his development, but good salesmanship and common sense also demand that he point out risks, economic problems, and known disadvantages. By squarely facing these issues and disposing of them in a logical way, he can make his future path easier.

Having prepared his presentation, the next problem is one of timing. There is a good time and a bad time to explode a revolutionary development on one's superior. A good salesman asks for an appointment, so that he can gain an audience at a favorable time. Plunging into the boss's office with a new idea, when the boss is already plagued with a number of immediate and pressing problems is not good salesmanship. Wait until you and your idea can get the right kind of hearing.

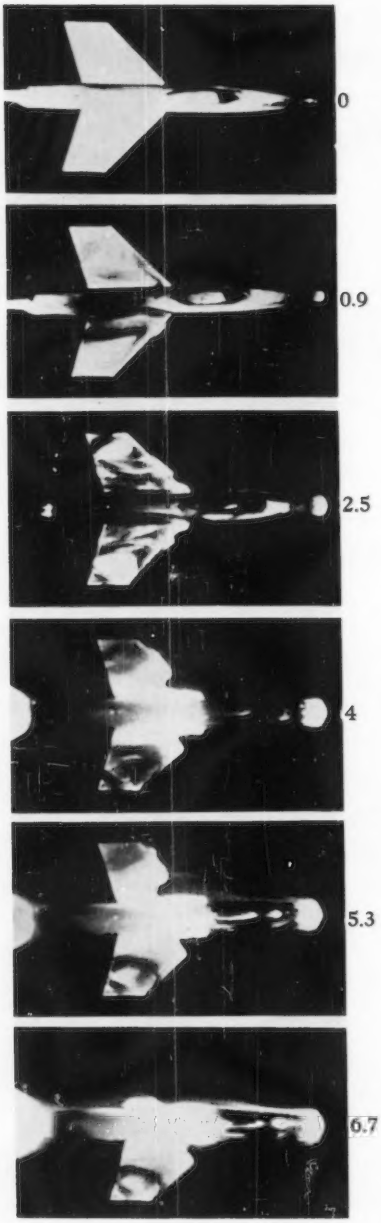
After making your presentation, don't press for a quick decision. Give the boss a chance to think about your development. You have lived with it for days or months; it's brand new to him. If you attempt to force an immediate decision, it may well be an unfavorable one. Leave an opening for future discussion. If you do get voted down, don't be discouraged. Try to find some new evidence or a more attractive approach to justify acceptance of your development.

Research results have to be sold. Industrial research—regardless of how fascinating it is to the research department—means nothing until the results are translated into something that can be made and sold. Few companies can sustain research that is not geared to commercial utilization.

In our zeal to develop new things, let's not forget the link that completes the chain and produces industrial profits. Let's do a more effective job of selling research results. This goal is not too far removed from the ASTM goal of "promotion of knowledge of materials of engineering."

[1] Vice-President, Pratt & Lambert, Inc.

Photographed in San Francisco at the meeting addressed by the ASTM 1956 Marburg Lecturer, Charles E. Reed, general manager of General Electric's Silicone Products Dept., were officers of the Northern California District and the cooperating societies. Standing, left to right, they are: R. W. Harrington, Vice-Chairman, ASTM District; Parker Dresser, District Councillor; Paul McCoy, Chairman, ASTM District; Dr. Reed; Jim Clayton, chairman, American Chemical Society; William Parle, president, Golden Gate Paint Production Club. Seated: ASTM National Director Paul Garin; Kenneth Palmer, vice-chairman, American Chemical Society; Bill Metcalf, treasurer, Golden Gate Paint Production Club; Fred Emonds, secretary, Golden Gate Paint Production Club; G. J. Grieve, Secretary, ASTM District; and Frank Mendes, vice-president, Golden Gate Paint Production Club.



Aerodynamic Heating

A stainless steel airplane model simulating 4500 miles per hour flight at an altitude of 50,000 feet, glows, melts, and disintegrates within 6.7 seconds.

Materials—

—KEY TO SUPERSPEED AIRCRAFT

NACA Devises Novel Equipment for Aero Heat Studies

In the span of half a century, aviation has progressed from the first powered flight at Kitty Hawk on Dec. 17, 1903, to airplanes that fly faster than the speed of sound. This rapid progress has been one of the wonders of modern science and engineering.

Guidance for much of the scientific work upon which this progress is based may be attributed to the National Advisory Committee for Aeronautics, better known as NACA, founded in 1915. NACA is an independent agency of the Federal Government, established by the Congress to "supervise and direct the scientific study of the problems of flight with a view to their practical solution," and to "direct and conduct research and experiment in aeronautics."

The basic goals of NACA's current effort are: (1) airplanes speedy enough to shrink the globe until any two points will be within a comfortable day's journey, and (2) ballistic missiles that can travel the required distances at the required velocities without being destroyed by aerodynamic heating.

The Problems of Superspeed

The conventional aircraft of today flies at subsonic speed or speeds below Mach 1, which corresponds to approximately 760 mph at sea level. Only a very few years ago, the frontier of aerodynamic research was in the transonic range from Mach 0.7 to 1.3. Today, military planes regularly break the sound barrier, and effective designs have been established. At speeds exceeding the speed of sound in the supersonic range, from Mach 1 to 5, and at hypersonic speeds above Mach 5, a new problem is superimposed upon all the other flight problems—that of aerodynamic heating.

In essence, aerodynamic heating is the conversion into heat energy of the kinetic energy of the air through which the airplane or missile is flying. This conversion takes place in the area of the shock wave and in the boundary layer where the air velocity is slowed as it approaches the body. The temperature increases as the square of the velocity. At Mach 3 about 2000 mph at altitude, the temperature would be about 660 F. At Mach 20, about 13,000 mph, the temperature would be about 20,000 F, far hotter than the surface temperature of the sun.

Testing Materials and Assemblies at High Temperatures

NACA conducts tests on materials and assemblies at its Langley Laboratory in Virginia. Laboratory investigation of aerodynamic heating at speeds which airplanes and short-range missiles may soon reach—below Mach 5—employ two general techniques: (1) equipment incorporating radiant-heat sources useful in the study of basic structural heating problems, and (2) facilities in which both aerodynamic heating and loading of a structure at a specific velocity can be duplicated.

High Heating Rates Necessary

In many of the ASTM tests involving evaluation of materials properties at high temperatures, the heating rate is relatively slow. For aerodynamic heating studies, however, test temperatures must be reached in a matter of seconds. Research tools being used for such investigations include an electric carbon-rod radiator which, when heated to about 4700 F, can produce heating rates up to the 100 BTU per sq ft per sec that would be experienced by a missile being accelerated rapidly to Mach 5 at low altitude. A more advanced type of heat radiator employs quartz-tube heat lamps that reach operating temperatures very rapidly and cool quickly. With this apparatus, such matters as the difference in thermal expansion of the aircraft skin and its stiffeners can be studied under closely controlled conditions.

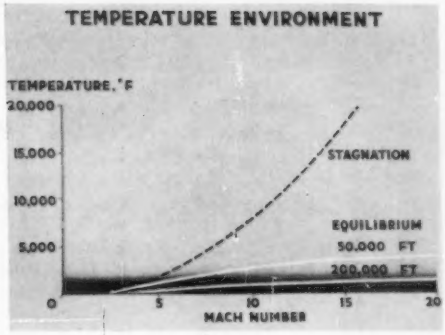


Fig. 1

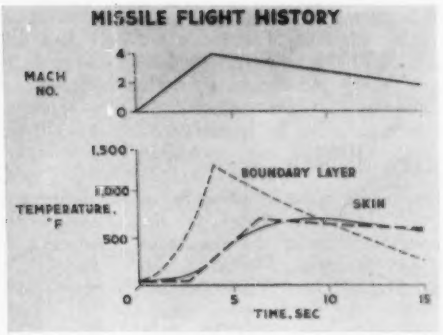


Fig. 2

While supersonic air jets have been used for some years in laboratory studies of aerodynamic heating, they have been of small size and provide limited though valuable information. NACA is presently constructing at its Langley Laboratory a supersonic airjet facility with a test section $8\frac{3}{4}$ by 6 ft, and the test range will be Mach 2 to 3. The air will be preheated in an accumulator holding 300 tons of stainless steel sheet to store the heat. Temperature up to 660 F, corresponding to Mach 3 flight at high altitude, will be provided.

Figures 1 and 2 which relate Mach Number with temperature, time, and altitude, illustrate the sort of environmental conditions encountered by superspeed aircraft and missiles.

Hypersonic Range Even More Severe

While heating problems in the range up to Mach 5 are difficult, they seem relatively simple when compared with those in the hypersonic range. To investigate hypersonic conditions in the laboratory, special equipment has been devised including shock tubes, special compressors, and light-gas guns. At the lower end of the hypersonic range, combustion-products tunnels are proving useful. They are essentially ramjet or rocket engines exhausting their hot jets into supersonic nozzles. Despite the fact that chemical composition of exhaust gases differs from that of air, these jets are valuable because they can be used to duplicate temperatures, velocities, and pressures of airstreams at speeds up to Mach 8 or higher. Results of a test with this type of equipment are shown on facing page. The series of pictures shows a stainless steel airplane model simulating the flight of an airplane traveling 4500 mph at an altitude of 50,000 ft. Approximate composition of the jet gas is 8 per cent oxygen, 35 per cent nitrogen, and 57 per cent steam. The pictures show first the nose and wing edges glowing, then the nose melts and grows blunter as the wings melt. Finally, the fusilage glows and the wings disintegrate. The model, which had a 2.-$\frac{1}{2}$in. wing span and $\frac{1}{8}$-in. thickness had almost totally disintegrated in 6.7 sec.

Another technique used in the laboratory to provide air at 4000 F corresponding to speeds above Mach 5, employs a heat exchanger lined with a ceramic refractory. The heat exchanger is also a refractory material in the form of millions of small spheres. Air is forced through the mass of heated spheres or marbles, then through a supersonic nozzle that must be cooled internally to keep it from melting.

Studies in Flight

To provide information not obtainable in the laboratory, NACA maintains several facilities for actual flight studies. At the High-Speed Flight Station at Edwards, Calif., aerodynamic heating is investigated in the Mach 2 to 3 range using full-scale research planes. Though one of these, the Bell X-2, was recently lost in a tragic accident, the program is being extended by the use of the X-1-B and X-1-E experimental airplanes. Under construction is the North American X-15 which is designed to fly faster and higher than man has ever ventured. This program is a joint effort with the military services, the aircraft industry, and the NACA.

At NACA's Wallops Island, Va., Field Station, 4-stage rockets are employed to provide heat data at speeds exceeding Mach 10. In order to reach such speeds it was first necessary to discover the reason for a disturbing series of failures in mid-air, at about Mach 4. It was found that the high rate of aerodynamic heating experienced for only a second or two, was to blame. The problem was solved by covering the leading edge of the cast magnesium fins of the second stage rocket with a protection of thin sheets of inconel. Performance data on the experimental models are provided by thermocouples positioned in the proper places and the information, together with that from pressure instruments and accelerometers, is telemetered in flight by a tiny radio transmitter in the model to a ground receiving station.

Flight Propulsion Studies

Studies of such propulsion systems as the turbo prop, turbo jet, ram-jet, and rocket engines are carried out at the NACA Lewis Flight Propulsion Laboratory in Cleveland. A number of wind tunnels are provided for studies on the propulsion systems either alone or incorporated in complete aircraft configurations. The Lewis Laboratory is the second largest consumer of electrical power in the Cleveland area.

Materials and Stresses

All aircraft engine designs could be greatly improved if the designer had a wider range of materials from which to choose, a more definite knowledge of the properties of materials, and a better understanding of how these materials will behave under any given set of conditions.

Very extensive facilities are available at the Lewis Laboratory for studying the properties of materials. Included are approximately fifty stress-rupture machines, photoelastic equipment, four tension testing machines, a number of spin pits, including two large enough to burst full-scale turbine wheels under operating-temperature conditions, a large amount of vibration-measuring equipment for use at high temperature, and an electronic differential analyzer. The laboratory is also conducting re-

search in physics of solids, particularly with respect to strength of materials at high temperatures. Among typical problems in metallurgical physics under investigation are sintering of powders, studies of creep and tensile strength, and studies of embrittlement of high-temperature materials by impurities.

How NACA Operates

NACA, as its name implies, has a committee structure. There is the main committee under the chairmanship of Dr. James H. Doolittle, who succeeded Dr. J. C. Hunsaker in October 1956. Under the main committee are 29 technical subcommittees. Members of these committees are selected because of their technical ability, experience, and recognized leadership in a specialized field, and they serve without compensation, in a personal and professional capacity. The main committee with its 17 members appointed by the President, establishes policy and plans the research programs to be conducted by the 7500 scientists, engineers, and supporting personnel who make up the staff of the NACA.

In addition to the program of research carried out in the NACA research centers, there is an extensive program of contract research at 25 nonprofit scientific and educational institutions including the National Bureau of Standards. By this means, scientists and research engineers whose skills and talents otherwise might not be available, contribute importantly to the Government's program of aeronautical research.

Through representation on NACA technical committees and subcommittees, as well as the Industry Consulting Committee, the nation's over-all program of aeronautic research in Government, in industry, and in the universities and research institutes is coordinated.

Whatever the future may hold in aeronautical progress it is certain that NACA will play a prominent part.

Motion Pictures of Metal Fatigue

THE National Bureau of Standards has constructed a small fatigue-testing machine equipped with a motion picture camera for filming the microscopic features of a metal surface during fatigue fracture. The apparatus uses a clock-controlled, 16-mm camera to take time-lapse motion pictures of aluminum specimens under torsional stress.

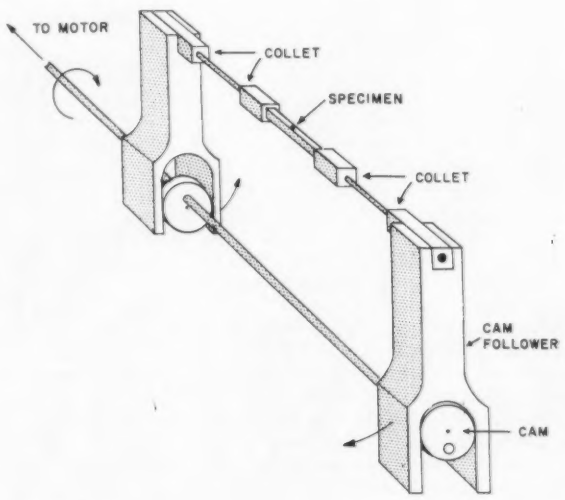
The base of the fatigue-testing machine is a block of steel designed to fit the stage of a metallurgical microscope. The base is machined at the top to a shallow U-shape, and a horizontal collet for holding the test specimen is inserted through the upper parts of the block. Two small eccentric cams are mounted at the ends of a motor-driven shaft passing through the lower part of the base so that cam followers can transmit the load to the ends of the collet above. The metal specimen to be filmed is pressed into the collet, and an alternation torsional load is applied through the cam followers by the cams, which are mounted 180 deg out of phase. The amount of load is determined by the degree of cam eccentricity. A 0.01-in. hole, drilled in the top surface of the specimen, provides a focusing target for the microscope. Any fatigue failure that occurs will tend to develop around the hole and thus be in the field of the microscope.

The camera is attached to the principal eyepiece of the microscope while a second eyepiece permits simultaneous visual observation. A large disk with a hole near its edge revolves on the motor shaft and serves as a shutter by interrupting the light to the microscope's vertical illuminator. This arrangement permits successive exposures at the point of the stress cycle. It is necessary because each frame may be exposed a number of times before another takes its place.

The film is advanced at regular intervals by a synchronous motor-driven cam that actuates the camera's single frame button, the camera shutter being adjusted to close only during film transport. Since the speed of the fatigue machine can be adjusted with respect to the movement of the film, the number of stress cycles per frame can be varied depending on how rapidly changes are taking place in the metal surface.

In order to obtain detailed information on fatigue for use in aircraft design, the National Advisory Committee for Aeronautics is sponsoring a Bureau study of the basic factors influencing fatigue crack initiation. The films made in the course of this investigation should simplify tedious laboratory determinations by providing automatically recorded, detailed pictures of the fatigue process.

Portions of the films taken during the early stages of the fatigue test showed no unexpected changes. Slip bands developed in the highly stressed regions around the hole, and these gradually became more numerous and heavier until some of them developed into cracks. During the latter stages of the test a crack developed in an area that had contained no slip bands in the early part of the test. A short time later material began to be extruded from this opening at irregular intervals, but in surprisingly large quantities considering the size of the crack. Since the crack was only 0.01 in. long and the extruded ribbon very thin, the actual amount of material driven out was extremely small. This phenomenon occurred suddenly and was not observed until the film was developed and viewed, so that no attempt could be made to collect the extrusion for chemical analysis. However, it has been suggested that the extruded material, if not an oxide of some kind, is so fine that it probably reacts immediately with the atmosphere to form one.



Fatigue Testing Machine

FROM PICO NO. 4. . .

By H. G. VESPER
Vice-President
Standard Oil Co. of California

TO PETROCHEMICALS

The California Oil Story*

THE ROMANTIC and engrossing history of the California oil industry is a story worthy of a Carl Sandburg or an Allan Nevins, and some day I hope a historian of their stature will be attracted to it and tell it in its entirety.

Taking a cue from the historians, I will start with a landmark—on a slope near the city of Newhall. It is a rather rare spectacle—a producing well that isn't making money. A squat derrick makes it actually look more like a windmill than an oil well. A diesel engine nearby runs it, and it is producing 1½ bbl of oil every day. This is Pico No. 4, the most famous of the early landmarks of our California oil industry. It was the first commercial well of any significance in the state and, indeed, in the West. It was drilled in 1876 and has been producing for these 80 years.

The well is in the rugged, barren Santa Susanna Mountains north of Los Angeles. The Santa Susanna is where three very large ranchos, Spanish grants, joined. The largest of these was the Rancho San Fernando, owned by two brothers, Pio and Andres Pico. Each of them left his mark on early California history. Pio Pico, in 1845, after an almost bloodless revolution, became the last Spanish Governor of Alta California. Andres, his brother, two years later was the commander of the last detachment of Californians defeated by General Fremont at Cahuenga.

Pio Pico, in a talk before a military council in Monterey in 1846, said: "We find ourselves suddenly threatened by hordes of Yankee emigrants. What that astonishing people will undertake next I cannot say, but in whatever enterprise they embark they will be sure to prove successful,"—and how right he was!

But it was not the Yankee emigrants, if legend is correct, who reawakened the Santa Susanna. It was Jesus Hernandes and Ramon Perea, who discovered several springs of water covered with a greenish substance. The discovery was in a canyon six or eight miles long, which subsequently became known as Pico Canyon. A match was lit, and the San Francisco *Post*, in an early version, said: "And applying it to the greenish substance it at once took fire, being an impossibility to extinguish it afterwards."

The Rancho San Fernando and its environs saw much prospecting activity. As the gold diggings wore out, silver, tin, copper, and lead each lured the prospectors on, but the one mineral of any moment, petroleum, was largely ignored.

Petroleum was an old story for the early Californians, for the country abounded in brea "tar" pits and seepages. Cabrillo, an early Spanish explorer, found Indians using oil at what is now the town of Carpinteria, a little north of Los Angeles, in 1542. In 1769, Don Gaspar de Portola discovered the brea pits on Wilshire Boulevard and seepages in the Santa Barbara region.

But even Government geologists of the '50's seemed unaware that these seepages had any value aside from their asphaltum content. True, asphaltum was soon being used to help in the paving of some of San Francisco's streets.

* Presented at the Petroleum Industry Luncheon during the ASTM Second Pacific Area National Meeting in Los Angeles, September, 1956.

But the demand was not enough to support an industry. A much more ready market was needed.

Oil for the Lamps

The beginnings of oil refining are also subject to speculation. One account is that Don Andres Pico tapped the seepages in Pico Canyon in 1855 and made oil for the San Fernando Mission in a "copper still and worm," but nothing came of it.

Credit for the first serious attempt at refining goes to a small group of San Franciscans. They were oil dealers, marketers of whale oil, burning fluid, and camphene, a mixture of turpentine and alcohol. In 1859, the year that Drake's Folly turned out not to be such a folly after all in Pennsylvania, one of these dealers began experimenting with samples of heavy crude which came from a shaft sunk in a brea bed. The goal was kerosine, but results were imperfect, to say the least. Nevertheless, on the strength of the experiment, a 400-gal "manufactory" was built near the shaft. The teapot affair, in operation by April, 1860, was unsuccessful.

It was this same dealer, George Gilbert, who, in 1861, sank a dry hole to 60 ft in search of oil in the Rancho Ojai, in Ventura County. This shared with another dry hole, also sunk in 1861, in Humboldt County, near Eureka, the fame of being the first attempt to drill for oil in California.

The Boom and Bust Begins

In 1864 a new era was born—a boom—the first of several boom and bust periods that have marked our history in California. This first one followed closely on the heels of the wild oil speculation that took place in the eastern states after the discovery of oil in Pennsylvania.

Early in 1864 a distinguished and colorful personality—Edward F. Beale, the United States Surveyor General for California—visited the springs in Pico Canyon. Beale and a Col. Baker, who was also a large Southern California landowner, made good in a court action their claim to Pico Canyon over Pio Pico and several other contestants.

In the summer of 1864 the nation's foremost authority on petroleum of the period paid a visit to California. Benjamin A. Silliman, Jr., founder of the Sheffield Scientific School at Yale University and professor of general and applied chemistry, shipped out of Boston Harbor and sailed around the Horn. It was Silliman's famous "Report on the Rock Oil or Petroleum from Venango County, Pa., with Special Reference to Its Use for Illumination, and Other Purposes" that gave the promoters of the Drake Well the support necessary to carry on. When he saw the seepages in Southern California, he concluded: "California will be found to have more oil in its soil than all the whales in the Pacific Ocean"—high praise indeed!

With the initial fee apparently underwritten by Beale, Silliman conducted a survey of the oil situation. His enthusiastic findings referred to both crude and refined oil in these words: "It is of a dark brown color, dichroic, thin, and mobile as water, and of a faint naphtha odor quite without offensive smell." He thought it "probable that a product of about 60 per cent would be obtainable suitable for illumination." He said the oil had a "very high illuminating power and fails to char or incrust the lamp wick after an hour's burning."

Of course, those of us in the oil business know how exaggerated those reactions were. But Silliman's report touched off a boom in California during which over 100 companies were launched in the state. Drilling equipment of considerable value was brought around the Horn. Wells were drilled, steam power made its entry, and oil was struck, but more grief than oil was discovered. Adverse reports contradicted the glowing analysis of Silliman and the bubble burst, even before word got out that the sample from Pico Springs had been "salted." The rush to locate "petroleum leads" came to a stop in the autumn of 1867. Oil held few attractions.

After the boom and bust, only a scant handful of people kept on looking for oil. For a time, San Franciscans continued to refine some kerosine from crude oil obtained by tunneling into the sides of hills. As a matter of fact, "mining" of this type had begun in the early '60's, and the Stanford brothers in 1866 completed an 80-ft tunnel which tapped certain steep, dipping oil sands in the Sulphur Mountain not far from Ojai. But soon even the tunnels were abandoned and the industry lay generally dormant until the early 1870's, when development began to take place on a more solid basis.

Pico No. 4

The center of this revival was the Pico Springs area. It was at Pico that an ex-Pennsylvanian, C. A. Mentry, began drilling in August, 1875. and subsequently brought in the first commercial production in the state. He used the so-called spring-pole drilling method—a sapling anchored in the floor of the canyon, weighed with boulders, with the bit suspended by rope from the top of the pole and attached to a leather stirrup. It was simply bounced up and down and by percussion the hole was drilled. By the end of the year Mentry had drilled three wells, the deepest being 120 ft. Total production, though only a few barrels a day, was by far the best up to that time by any venture in the canyon. The fourth well, Pico No. 4, came in 1876 at the tremendous production of 18 bbl a day. When deepened to 560 ft by a steam rig, it yielded 70.

In the summer of 1876, the California Star Oil Works was formed to exploit the new development. This was a forebear of the Standard Oil Co. of California. Principal among its assets were these Pico wells, particularly Pico No. 4. A small refinery was erected nearby at Newhall and another near Ventura, and by 1879 there was enough production to justify laying a 2-in. pipeline from the Pico area to the Newhall refinery.

All this notwithstanding, 1878 was a year of near disaster. Pennsylvania production flooded the East with oil. Prices tumbled, and hard times came on the new industry in California. It was largely due to the efforts of two individuals, Charles Felton, banker and former Assistant Treasurer of the United States in charge of the San Francisco Mint, and Lloyd Tevis, president of Wells Fargo, that the industry was kept from going under.

Rise of the Companies

Perhaps their biggest stroke was the founding of the Pacific Coast Oil Co. in 1879. This was a new type of company for the California industry. It was well financed; capitalized at $1 million with the entire amount paid in. It had a scope of operations unknown to the earlier corporations which had only limited paid-in capital. Among the interests it acquired was the California Star Oil Works and Pico No. 4.

Pacific Coast Oil Co. soon became almost synonymous with the California oil industry. In 1880 it opened a refinery at Alameda, across the bay from San Francisco, which had a capacity of some 500 bbl a day. Its range of products was wide: two grades of kerosine, lubricating oil, machine oils, and headlight oil. Its markets included some very faraway places for those days—British Columbia, Mexico, and Sandwich Islands, and the Society Islands. One newspaper said at the time: "This we think will clip the wings of Standard Oil on this Coast." The Standard Oil Co. of the East, meanwhile, had become a marketer in California in 1878.

Drilling activity backed by financial stability carried forward, although as late as 1887 the only companies actually engaged in petroleum "mining" were:

the Puente Oil Co. in Los Angeles County; the Hardison & Stewart Oil Co., subsequently incorporated as Union Oil; and the Pacific Coast Oil Co., operating in Pico Canyon and in a place called Moody Gulch.

The principal problem was not one of production but of refining from asphalt crudes. The market was essentially for kerosine but refiners could get only a low-grade product which could be sold only after blending with eastern kerosine. It was clear that there had to be a much broader base for this new industry. Very fortunately for California oil, the coal stratum of the region bordering the Pacific is of relatively minor importance. The coal is relatively low in BTU, cokes with some difficulty, and is high in ash. Gas companies first began to experiment with and later to use oil as a substitute for costly imported coal, and gradually other industries in the state turned to fuel oil as a basis for their energy input. A new market developed; fortunately, the cost of West Coast fuel oil was relatively low, so fuel oil from other areas could not compete here.

As production increased and the new market developed, the western industry became of increasing interest to Standard Oil men in the East. After two attempts to acquire Union Oil Co., Standard Oil entered the production and refining picture through the purchase of Pacific Coast Oil Co. in 1900, and thus rounded out its entry as a marketer on the West Coast.

So, in about a quarter of a century, California had grown to national significance in the oil picture. In 1900, the state was fifth in national production; three years later it was in first place. Certainly those "astonishing people" referred to by Pio Pico had accomplished a great deal.

The Modern Industry Emerges

Up until 1900 most of the production had been confined to Southern California, but for the next 20 years the center moved into the San Joaquin Valley and to other parts of the state. California embarked on several eras of feast and famine that, as I remarked earlier, have been somewhat characteristic of our industry in the West. It was during this time that the corporate structure of the California oil industry began to assume a somewhat familiar aspect.

In 1901 the Associated Oil Co. was formed by a group of San Joaquin Valley producers. Later, this company and the Tidewater Oil Co. of the East and Middle West were to become the Tidewater-Associated Oil; more recently, the Tidewater Oil Co. Also in 1901, California Oilfields, Ltd. was formed. This, in effect, marked the entry of Shell into California and the United States because in 1913 Shell Transport and Royal Dutch Petroleum purchased the Limited.

In 1905 the Kellogg Oil Co. was formed to operate a small still in the Los Angeles area. To this, although many other branches went into its formation in later years, is traced the Richfield genealogy. The same year the Esperanza Oil and Gas Co. was started and drilled extensively in the San Joaquin Valley. In 1910 a new company was formed to take over these properties and to engage in refining and marketing—the Esperanza Consolidated—which in 1912 became known as the General Petroleum Co., now Corporation.

Over this 20-year period fuel oil became without question one of the dominant factors in the economic development of the West.

The center of production shifted back in the '20's to the Los Angeles Basin and, like the nation, California entered the era of overproduction. In the '30's there was a gradual voluntary curtailment of production, and then came the war. California was asked to expand its production greatly, and California did—45 per cent over the prewar figure, whereas the national average increase was only 26 per cent.

Now an Importer

Now, postwar, we find ourselves in a completely new situation—an importer so far as raw material is concerned. In 1955 the West Coast imported nearly 100,000 bbl a day of crude oil. This change-over, of course, is nothing but a reflection of the complex economy that has evolved in the West Coast. Prior to World War II, our economy was based largely on the production and processing of foodstuffs and raw materials. But with the war came the development of a tremendous number of industries—aircraft, shipbuilding, aluminum, steel, electronics, atomic energy, and many others. Industrial employment expanded rapidly and population rose to record heights.

In the postwar period, the population and industrial growth has greatly exceeded the national average. I might illustrate this by a few comparisons between 1955 and 1940: In terms of population, the West Coast has increased 74 per cent and the national average has gone up 24 per cent. Personal income in the West has gone up 158 per cent; nationally, 102 per cent. Manufacturing employment, 119 per cent in the West; nationally, 56 per cent. Moreover, California's permanent population is increasing by about 1000 people every day. Visualize a whole new town of 7000 people every week!

The demands of the economy on the oil industry have continued to expand with this growth. Very fortunately for industry in general, the West Coast is just about self-sufficient in terms of fuel oil and has a petroleum industry that supplies 60 per cent of the energy demand. Nationally, that figure is about 44 or 45 per cent. So, there is no question that the industrial growth of the West has been inextricably linked to the development of the petroleum industry. Certainly we can say that the wheels of industry have been greased by the oil business. Too, oil has brought untold wealth to California. Over the years since 1849 and '50, so far as gold is concerned, and the 80 years that we have produced oil in California, the value of the oil has exceeded that of the gold by a ratio of about 6 to 1. Possibly oil is really the gold that has been found in the West.

Potential Resources

I don't know what the future will bring in our attempts to supply sufficient raw material in the West to meet our petroleum demands. Certainly there are several things that will be helpful.

We look forward to a very active development of offshore oil reserves. Legislative problems have slowed this down but we are very hopeful that this activity will now go forward rather rapidly. There are many technical difficulties in the way, of course. The shoreline slopes off rather rapidly, and drilling in deep water is very difficult and expensive. But while there are obstacles yet to be resolved, there is hope for an estimated production offshore in excess of 100,000 bbl per day five years from now.

On land, exploration is going forward very rapidly. Some success has been achieved in Arizona and Nevada. Exploratory work continues in Alaska, Oregon, Washington, and other states. Great emphasis is being placed on improved recovery from existing fields and secondary recovery. One of the most interesting approaches in the latter is currently being tried in the San Joaquin Valley. It is a full-scale trial of "underground burning"—actually setting a fire in oil sands several thousand feet below the surface to generate pressure to drive more of the oil to the surface.

I am very confident that we will improve our raw material supply by these means. But be that as it may, I have one abiding faith about this dynamic and resourceful oil business of ours—no matter what the demands may be, they will be met.

So, as we do look forward and down the road, I have no doubt that the oil industry will do its share to keep pace with the development of the West.

THE FIRST 50 YEARS OF COMMITTEE D-10

The Problem of Boxing Explosives Spurred the Activity that Resulted in the ASTM Shipping Container Committee

EDITOR'S NOTE.—A number of technical committees of the Society have reached or are nearing the celebration of the 50th anniversary of their organization. Some are taking special cognizance of this in one way or another. Many of them are interested in having a historical record of the Committee and its work. Committee D-1 on Paint, for example, sponsored a complete Symposium covering 50 years of paint testing.

In anticipation of a similar event, the history of Committee D-10 on Shipping Containers has been prepared by Earl R. Stivers, its present Chairman. An abstract from this article is given below.

Possibly of particular interest to the reader is the fact that the Committee was organized as a Committee on Explosives, but later developments and experience, as indicated in the article, indicated the desirability of changing the committee to one on Shipping Containers.

At the 16th Annual Meeting of the American Society for Testing Materials, held at Atlantic City, N. J., in June, 1913, Col. B. W. Dunn presented a paper on "Conservation and Shipping Containers."[1] In this paper he discussed the tremendous loss to our national resources through damage to railway freight, as a direct result of poorly constructed shipping containers. In an effort to secure a definite action as a result of his strong plea Col. Dunn proposed:

Resolved, that the American Society for Testing Materials, on account of its desire to cooperate and assist in any action that promises to conserve our national resources, respectfully urges upon the Interstate Commerce Commission, the advisability of extending, to all classes of freight moving in interstate commerce, the protection against damage and loss through insecure shipping containers that the Commission is now endeavoring to extend to explosives and other dangerous articles; and this Society offers the services of a committee, whose appointment for this purpose is hereby authorized, to assist, so far as the time and experience of its members may permit, in formulating and perfecting standard specifications for shipping containers.

This recommendation was approved by the Executive Committee of the Society on October 6, 1913, thus creating Committee D-10 on Shipping Containers, with an invitation to Colonel Dunn to act as temporary Chairman.[2] At the first regular meeting of the Committee, on January 8, 1914, in New York, N. Y., Dunn was elected permanent Chairman of a committee of 19 members. At this meeting is was decided to prepare a list of all types of shipping containers then in use and to compile all obtainable information as to specifications for the same. At the second meeting in Atlantic City, N. J., on July 22, 1914, the magnitude of this task was revealed as 35 classes of containers were assembled. This report pointed up the necessity for standardization of shipping containers and particularly tests which would be necessary to back up these standards.

Containers for Explosives

At that time both Col. Dunn, Chairman, and W. S. Topping, Secretary, were the chief inspector and assistant chief inspector, respectively, of the fairly young Bureau of Explosives. The Bureau was then beginning the task of setting up specifications for boxes used in the transportation of explosives and dangerous articles. Dunn was convinced of the necessity of a standard test to determine the efficiency of such containers and suggested a simple 4-ft drop test for this purpose. In view of the lack of control of such a test, G. C. Babcock and W. A. Fairburn independently undertook the development of a more standardized type of machine. Babcock demonstrated this machine at the third meeting of the committee, in Chicago, Ill., on November 13, 1914. It was a cylindrical drum 4 ft in diameter and 4 ft deep. Along the side of the drum were inclined guides to shift the box to tumble end over end and drop it from side to side. Although this machine brought out clearly some of the

An Early Revolving Drum for Container Testing

[1] *Proceedings*, Am. Soc. Testing Mats., Vol. XIII, p. 1072 (1913).

[2] The first appearance of Committee D-10 is in the minutes of the Executive Committee, April 4, 1910, when it was approved as Committee D-10 on Standardizing Explosives but the records do not show that the committee was actually functioning so it was discharged October 6, 1913, when the change was made to Committee D-10 on Shipping Containers. Preceding the formation of Committee D-10, tests had been conducted and studies made on wood shipping containers by Professor W. K. Hatt, at Purdue University, in 1905 and by the Forest Products Laboratory following its establishment in 1910. These early studies were based on static test conducted in a compression machine.

defects of the various box designs, it permitted the box to roll side over side or end over end in a manner which failed to provide a sufficient variety of treatment to bring out weaknesses in construction. This apparatus appeared to have such great promise that a subcommittee was appointed to study the drum tester, and funds were provided by the National Association of Box Manufacturers, the Wirebounds Corp., and the Fiber and Corrugated Strawboard Box Assn.

The committee meeting of June 23, 1915, was devoted largely to the problem of devising suitable testing machines. The early testing machines used in industry had proved unsatisfactory in many respects and the development and improvement of testing machines overshadowed all other work of the committee. The most significant development of this meeting was that the Forest Products Laboratory, of the U. S. Department of Agriculture, at Madison, Wis., would welcome the cooperation of Committee D-10 in the development of tests for shipping containers. The Forest Products Laboratory was, at that time, greatly expanding its activities due to the urgent impetus of shipping and the attendant packaging problems during the early months of World War I. The Laboratory had already been represented on the Committee by J. A. Newlin and it was under his direction that the newly designed revolving drum test machine was further developed and constructed with the committee's funds, at Madison. The Laboratory had already been working on a small revolving drum at the time of this meeting; therefore, had a background of experience for this type of test.

Ancestor of the Revolving Drum

During the next year, the subcommittee on testing, in cooperation with the Forest Products Laboratory, developed a machine essentially the same as the present 7-ft revolving hexagonal drum. Considerable time and effort had been necessary to determine the correct size, dimension, and angle of the hazards, and the speed of rotation. At the 1916 Annual Meeting, the subcommittee reported that a suitable machine had been developed and final engineering drawings of the drum and internal hazards were then made available to the Society by the Forest Products Laboratory. In the 1916 *Proceedings*[3] of the Society, J. A. Newlin and T. R. C. Wilson reviewed this developmental work in a paper entitled, "The Development of a Box Testing Machine and Results of Tests".[3] Shortly thereafter, Babcock had a second revolving hexagonal machine installed at the Wirebounds Corp. Testing Laboratory, in Chicago, Ill. The speed with which this project was prosecuted and brought to a successful conclusion speaks eloquently of the caliber and interest of the members of Committee D-10 during this initial period.

[3] *Proceedings*, Am. Soc. Testing Mats., Vol. XVI, Part II, p. 320 (1916).

War Impetus to Work

The original resolution made by Dunn for the establishment of Committee D-10 specified the formulation and the beginning of standard specifications. In this direction, the Committee published in 1917 their first tentative specifications for: Canned Food Boxes, Nailed and Lock-Cornered Construction (D 44-17 T); and Canned Food Boxes, Wirebound Construction (D 45-17 T). By this time World War I has assumed gigantic proportions and the urgency of obtaining adequate shipping containers for the Armed Forces proved the foresight of the work of Committee D-10 in developing test methods and specifications. The Forest Products Laboratory soon found the 7-ft drum too small for many shipping containers and a new model of this drum was made essentially doubling the dimension of the 7-ft drum. On October 25, 1917, the Forest Products Laboratory released drawings for this new drum and a contract for its construction was made shortly thereafter. The Wirebounds Corp. also had constructed a 14-ft revolving drum and subsequently, numerous 7-ft and 14-ft drums were constructed for testing laboratories throughout the United States.

The 1919 Annual Report of D-10 reviewed the association of committee members with the War and Navy Departments and the U. S. Railroad Administration for the preparation of specifications, design of containers, and the standardization of packaging methods. The Forest Products Laboratory during this time was cooperating with every government activity in the entire field of shipping containers.

The 1920 Annual Report enumerated 12 organizations which were taking an active interest in better shipping containers. At that time, members of Committee D-10 were in close touch with all of the agencies and several members of the committee were participating directly in their program for making tests and considering specifications for the same.

The further work on specifications by the Committee was evidenced in 1925 by the publication of tentative specifications for: Wooden Boxes, Nailed and Locked-Corner Construction (D 68-20 T), and the following year by the publication of tentative general specifications for 4-One and Similar Type Boxes (D 118-21 T), and a new subcommittee on Tight Barrels was established.

The 1922 Annual Report of the committee makes reference to the Bureau of Explosives expanding its tests and specifications to include shipping containers for all kinds of commodities. Mention is also made of new Freight Containers Bureau, and the statement that, "the action of the A.R.A. clearly shows the wisdom of ASTM in forming Committee D-10 a number of years ago, and will enable that committee to give, as well as receive, valuable assistance in the formation of proper standards for shipping containers."

The Need for Methods of Test

Following 1920, several of the members of Committee D-10 were instrumental in setting up container testing laboratories within the industry. These new laboratories constructed apparatus along the lines outlined by Committee D-10 as well as significantly contributing to research on container testing apparatus and new approach to containers. Following World War I, the field of shipping containers grew to such diversity that the need for specifications in any particular type of package was overshadowed by the need for standard methods of test. The 1930 Annual Report states that, "the time is opportune for a general revision of the ASTM Specifications for shipping containers and for the preparation of new standards, not only to deal with specifications for containers but also with the materials, nomenclature and methods of test. With these thoughts in mind, the subcommittees have been entirely reorganized." Also, "much confusion has arisen from the lack of standard definitions of terms." But, though the time may have been opportune, nothing seems to have been done except perhaps in the laboratories of the members. To them the depression was a time of challenge to learn more about shipping containers and develop design tables and new types of containers to keep their industry in the forefront.

In 1934, prominent members of the Committee held a meeting to formulate the future program of work of the committee. It was the consensus of those present that the necessity for the Society to do work on specifications of design and construction had largely passed. That the scope of the committee should in the future be confined to those functions which are admittedly within the field of ASTM activities, such as methods of testing containers and test methods, and specifications for materials to be used

in containers where no other standing committee of the Society was preparing such specifications, and that the present specifications for shipping containers should be withdrawn. This recommendation resulted in the withdrawal of the four D-10 specifications. The subcommittees of Committee D-10 at this time were based on the broad classification of the type of shipping container. This structure remained until the beginning of World War II.

World War II created an immediate demand for standards in the shipping container field. With this increased interest, the members of the committee rose to 61 and growth of the committee activities included the promulgation of a revision to the revolving drum test, a proposal for a vibration test for shipping containers, and a new method of impact test using an inclined track, bumper, and dolly.

Scope Expanded

In 1950, the scope of the Committee was enlarged to include packages and pallets, as follows:

Scope: Nomenclature, Definition of Terms, Test Methods, Performance Specifications, and the study of the effect of various factors influencing strength and serviceability relating to packaging, including packages, shipping containers, and pallets.

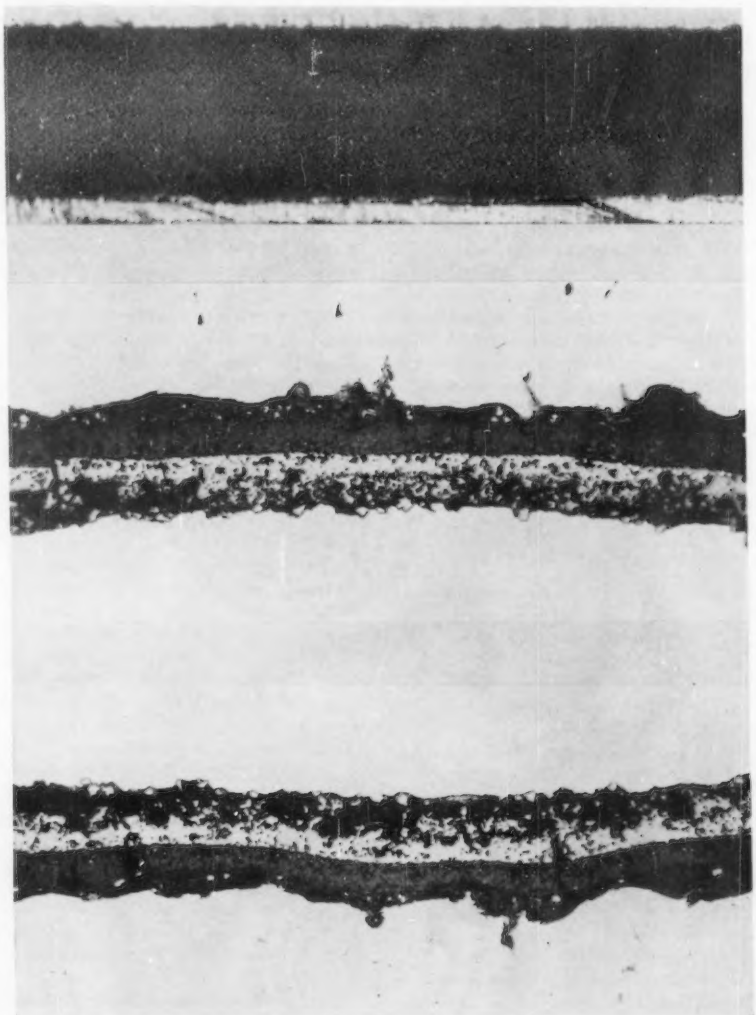
With test methods adopted, Subcommittee V on Correlation of Tests and Test Results initiated a collaborative drum test program for the determination of variations between drum testers and test results. The results of these interlaboratory tests indicated a large variation between testers. A collaborative program for the drop test was next undertaken which indicated even more variability between laboratories than the drum test. In the meantime, a task force was setting up a preliminary program to measure shock and vibration utilizing strain gages and oscillographs.

In 1953, the Annual Report records the unfortunate passing of T. A. Carlson, Chairman of Committee D-10 for 6 years and longtime employee at the Forest Products Laboratory, expressing with deep sincerity its great loss of an esteemed Chairman and sincere friend. G. E. Falkenau and R. F. Uncles, the present Chairman and Secretary respectively, were elected by the committee members now numbering 106. The activities of Subcommittee II on Methods of Testing, Subcommittee IV on Performance Standards, and Subcommittee V on Correlation of Tests and Test Results were coordinated in order to carefully determine, if possible, the reason for the wide variation in the results from the apparatus used to assemble shipping containers. As a result, effective interlaboratory collaboration test programs were set up to study the revolving drum test, the drop test, vibration test, and stacking test of shipping containers. This program has been active since 1953, and, when complete, a comprehensive study of instruments, orientation, vibrations in apparatus and other factors affecting the test method results will be used as a basis for revision to eliminate or diminish the wide variations in test results from one apparatus to another.

Graduate Study and Research at Carnegie Tech

A NUMBER of third-time and half-time teaching and research assistantships, and graduate fellowships are available to graduate students in various departments of the College of Engineering and Science of Carnegie Institute of Technology.

Inquiries concerning applications should be addressed to Dean of Graduate Studies, Carnegie Institute of Technology, Pittsburgh 13, Pa.



Metal Transport of Stainless Alloy by Liquid Lithium.
First Prize, Macrographs—Tenth ASTM Photographic Exhibit. Mildred Ferguson, Babcock & Wilcox Co. Research Center, Alliance, Ohio.

Activities of Committee D-2, June, 1955 to June, 1957—A Summary

The work of ASTM Committee D-2 on Petroleum Products and Lubricants for the period June, 1955, to June, 1956, and a look ahead to June, 1957, are summarized in this article. The activity is presented in sections on Fuels, Lubricants, Other Products, Measurement and Sampling, and Analytical Methods.

ACTIVITY is continuing at the high level of the past several years. The 1956 Report to the Society which totaled 150 pages was the second largest ever presented by Committee D-2. Plans of the subcommittees indicate a full program through June of 1957.

Fuels

Technical Committee A on Gasoline, *H. M. Smith, Chairman*

Specifications for Gasoline (D 439) are reviewed as a regular part of the work of Technical Committee A. This year the minimum octane number requirements for regular and premium gasolines were increased so that the specification reflects the antiknock quality of motor fuels currently available. Also, the Appendix to Specifications D 439, which describes the significance of the inspection tests for motor gasoline, was revised to bring it in close conformity with the new enlarged edition of the *Significance of ASTM Tests for Petroleum Products, STP No. 7-B.*

As mentioned in the previous summary in the April, 1956, ASTM BULLETIN, Committee A has continued its discussion of extending the antiknock scale so that motor gasolines of over 100 octane number could be included.

As a result of extensive review, balloting, and evaluation of all opinion, the committee made firm recommendations for the scale to be used over 100 octane number. These were transmitted to Research Division I and are mentioned under the activities of that group.

Other work on motor fuels includes improvement of test methods to measure vapor pressure, study of deposit formation, and the problem of staining automotive finishes by gasoline. Of these items, the Coordinating Research Council is conducting a program designed to provide better criteria for vapor lock and other performance factors where volatility of gasoline is involved.

Staining of finishes by gasoline will be reviewed by ASTM Committee D-1 on Paint, Varnish, Lacquer and Related Products, in cooperation with Technical Committee A.

Basic studies of the mechanics of gasoline gum formation are being sponsored by Army Ordnance at the Bureau of Mines and Stanford Research Institute. The committee is maintaining liaison to keep informed of the results of the program.

A Symposium on Vapor Phase Oxidation of Gasoline was held in September, 1956, in conjunction with the Los Angeles meeting of the Society. These papers will be published as a *Special Technical Publication.*

Technical Committee J on Aviation Fuels *J. J. Harrington, Chairman*

Review of Specifications for Aviation Gasolines (D 910), a continuing activity, resulted in the recommendation of new dyes for coloring the various grades of aviation gasoline and new color standards for evaluating the color of the dyed gasolines.

Section VII on Jet Fuels has continued discussion of commercial specifications for aircraft turbine fuels. Study is expected to result in a set of ASTM kerosine-type fuel specifications during 1957.

Other work on jet fuels includes consideration of improved test methods for flammability and autogenous ignition, in cooperation with Technical Committee N on Hydraulic Fluids; and a test to predict filterability, under development in Research Division V on Analysis of Fuels.

At the request of Technical Committee J, a new section has been organized in Research Division VII on Flow Properties to study the flow characteristics of jet fuels at low temperatures. Work is directed toward the eventual development of a test method for pumpability of jet fuels.

Consideration is also being given to improved burning tests, and in cooperation with the Coordinating Research Council, tests for thermal stability.

Technical Committee E on Burner Fuel Oils *R. C. Wright, Chairman*

The committee met in June, 1956, after several years of inactivity. A Proposed Method of Test for Thermal Stability of Boiler Fuel Oil was approved for publication as information. Work planned includes a review of the Specifications for Fuel Oils (D 396) and formation of a section to study stability of fuel oils. A symposium on this subject may be organized.

Technical Committee F on Diesel Fuels *W. K. Simpson, Chairman*

The committee is attempting to arrive at revisions to the Classification of Diesel Fuel Oils (D 975), that are acceptable to the groups represented.

Research Division I on Combustion Characteristics *F. C. Burk, Chairman*

In addition to its regular work of maintaining the ASTM Engine Test Methods D 357, D 908, D 613, D 614, and D 909, projects to advance fundamental knowledge in the art of engine testing were initiated.

As a result of recommendations from Technical Committee A on Gasoline, the Division is preparing revisions of the Motor (D 357) and Research (D 908) methods which will incorporate procedure for rating fuels of over 100 octane number. Present plans call for recommendations for suitable revisions to be made to Committee D-2 in 1957. Description of the proposed scale and reference fuel system are available from W. T. Gunn, Secretary of Committee D-2. It is also published in the compilation of "ASTM Standards on Petroleum Products and Lubricants," November, 1956.

The planned application of the Motor Method D 357 and Research Method D 908 to motor fuels of over 100 octane number has resulted in a related project to improve their precision in this range. Changes in design will be reviewed by a section on test equipment development.

Principles of the temperature-density concept (TD) have been incorporated in the Research Method D 908 in order to reduce the effect of barometric pressure on ratings. Application to the Motor Method D 357 and Aviation

Method D 614 is being investigated. For a description and summary of the basic work that preceded incorporating TD concepts in the Research Method, reference should be made to ASTM *STP No. 186*, "Methods for Reducing the Effect of Barometric Pressure in Measurement of Octane Number," by Bruno R. Siegel.

The Cetane Method D 613 for obtaining ignition quality of diesel fuels now includes new instrumentation. The new instrument, called the ECS-1 meter, is superior to the former coincident-flash equipment and will be the sole means of measuring the ignition delay after June 1, 1957.

Carburetor cooling has been incorporated into the equipment and procedure for the motor, research, and aviation methods. The equipment permits the rating of fuels of high volatility which formerly caused difficulty.

Other projects include development of new standardization fuels for engine checks, and a statistical review of data on the minimum detectable octane difference at levels of 50, 75, and 99 octane number for the Research Method.

Efforts to find better primary reference fuels for the Cetane Method will continue.

A new ASTM Manual for Rating Fuels by Motor and Research Methods was published in 1956 and is available from the Society. Two more manuals, one covering the Aviation and Supercharge Methods, and the other the Cetane Method, are in preparation.

Research Division V on Analysis of Fuels *C. A. Neusbaum, Chairman*

The Division is working on a problem referred to it by Technical Committee J on Aviation Fuels, namely, the development of a method to detect the presence of other liquid fuels in aviation gasoline. In response to another request, information was given to Technical Committee J on a procedure to detect solid contaminants in jet fuels.

ASTM Method D 95, Test for Water in Petroleum Products and Other Bituminous Materials, was revised. The revision completes several years of work on the method in cooperation with Committee D-4 on Road and Paving Materials.

Research Division VIII on Volatility *R. J. Askevold, Chairman*

The important inspection tests for distillation, flash point, and vapor pressure received attention. The continued review of these methods will be on the Division's future work program.

Method D 86 for distillation of gasoline, kerosine, naphtha, and similar products was revised by including an improved section on precision based on an extensive cooperative program, in which 34 laboratories, representing 19 companies, participated. Five samples were cooperatively tested, namely, winter grade gasoline, summer grade gasoline, ASTM precipitation naphtha, Stoddard solvent, and kerosine.

For each stage in the distillation of each sample, repeatability and reproducibility were calculated at the 95 per cent probability level in accordance with the recommended practice published by Committee D-2. Over-all averages of thermometer readings were used in estimating the rate of change of thermometer reading per per cent evaporated or recovered at each stage in the distillation of each sample. From these data, the best fitting linear equations were derived to express repeatability and reproduciblity as functions of the rate of change of thermometer reading. The presentation of precision in Method D 86 in nomograph form, was based, in turn, upon these equations.

During the year, over-all improvements in the distillation methods were reviewed. A full-range distillation thermometer and consolidation and simplification of apparatus and procedure for Method D 86, Methods D 216 (natural gasoline), and D 158 (gas oil and distillate fuel oils) are being considered. Although no recommendations have yet been made to Committee D-2, there is evidence of progress and the work will continue.

Flash point methods D 56 (Tag Closed Tester) and D 92 (Cleveland Open Cup) have been revised and completely rewritten. New sections on precision are included in the revisions.

The standard method for vapor pressure of petroleum products, D 323, was revised to include crude oil in its scope and to make 100 F the preferred temperature. A cooperative program is being planned to evaluate the precision of the method when applied to samples of low vapor pressure.

A revision of Method D 323 is being planned that will incorporate the procedure and apparatus for null point vapor-pressure determinations. A description of the essential parts of the procedure is given in Appendix VIII of the 1952 Report of Committee D-2. Since 1952, refinements have been made which will be given in the proposed revision.

Method D 1160 for vacuum distillation was revised to incorporate checking of the assembled apparatus by distilling cetane. Glass vacuum-jacketed apparatus was approved as an alternate to the asbestos-insulated equipment now specified.

Careful study is being given to the inclusion in Method D 1160 of a vapor-pressure correction procedure for deriving corresponding vapor temperatures for pressures other than the pressure maintained during the test.

Research Division XI on Calorimetry *A. J. Kraemer, Chairman*

The proposed test for estimation of heat of combustion of liquid petroleum products was published as tentative (D 1405) in 1956.

The Division has continued its work to revise the bomb calorimeter method for heat of combustion of liquids (D 240). Cooperative testing of aviation gasoline, jet fuel, and kerosine samples has been undertaken. Evaluation of the results of this program should result in a revision of Method D 240 within the near future.

Lubricants

Technical Committee B on Lubricating Oils *W. S. James, Chairman*

Development of a system for expressing the viscosity of industrial lubricants is continuing. The American Petroleum Institute and The American Society of Mechanical Engineers (ASME) are being advised of the work and may take part in the program.

A tentative method for galvanic corrosion associated with instrument oils in contact with dissimilar metals will be proposed in 1957. Attention is also being given to methods for evaluating the spreading tendency of lubricating oils, particularly those of the "non-spreading" type.

The subsection on railway car journal lubrication is following the proposals in the Association of American Railroads to specify a 100 V.I. oil for car journal lubrication. A cooperative study of such an oil, in the Falex tester, is being considered. Both straight oils and oils with extreme pressure additives will be tested.

Method D 322, dilution of crankcase oils, is being studied in order to improve procedure and equipment. An alternate procedure using a vacuum distillation technique is also being reviewed.

The test for foaming of lubricating oils, Method D 892, has been given a detailed review during the year. Particular attention has been given to variables in the diffuser stones and the effect of pore size of the stones on test results. There seems to be no correlation of porosity and foaming of the oils under test. Efforts to improve agreement of results between laboratories will continue.

Cooperative work with the API on its "Classification of Internal Com-

bustion Engine Service to Guide the Choice of Crankcase Oils" is continuing. A new edition of the classification was published this year in which the views of the committee were considered. It is planned to attempt to develop a technical language for use by petroleum and automotive technologists which will supplement the general language used in the API classification.

An ASTM Symposium on Lubricating Oils, organized in cooperation with Research Division III on Elemental Analysis, was held in Los Angeles in September in conjunction with the Second Pacific Area Meeting of the Society.

Research Division VII on Flow Properties *J. C. Geniesse, Chairman*

The Division has two active projects which were started within the year:

The American Petroleum Institute may be requested in the near future to increase the viscosity oil standards to seven. (Three standards—Alpha, Beta, Gamma—are now being supplied.) The viscosity range (3 to 2000 centistokes) is approximately the same, but the increased number of standards will narrow the range of viscosities for each and permit more flexible calibration. Also, a standard for temperatures as low as −65 F is being considered to meet the need for accurate viscosity determinations at this low temperature.

As a result of the symposium on viscosity index systems held in Dallas in February, 1956, the Division and Technical Committee B have organized a joint committee on viscosity-temperature relationships under the chairmanship of J. C. Geniesse. Its general objective is the development of a system for predicting the viscosity-temperature characteristics of petroleum products which would eliminate the inconsistencies in the ASTM method for calculating viscosity index (D 567). Several alternate procedures have been proposed and are being evaluated. A summary of the 1956 Symposium appears in "A Comparison of Viscosity-Index Proposals," by J. C. Geniesse, ASTM BULLETIN, July, 1956. A second symposium is being planned which will further acquaint the user with the good and bad features of the proposals.

A new section has been formed to study flow characteristics of jet fuels. A pumpability test for jet fuels at low temperatures may result. Other work on pumpability of heavy fuel oils is continuing. Reports on the program and on a method for stable pour point are expected to be published soon.

ASTM Viscosity Tables, *STP 43 A*, may be revised by including an additional conversion table from kinematic viscosity to Saybolt Furol viscosity at 210 F. Method D 88, Saybolt Viscosity, was revised in 1956 by the addition of a procedure for waxy or resinous samples.

A provision may be added to Method D 97, Cloud and Pour Points, to provide improved procedure for the testing of samples containing water.

Research Division VI on Analysis of Lubricants *J. B. Rather, Jr., Chairman*

Editorial revisions have been made in Methods D 664, Neutralization Value by Potentiometric Titration, and D 939, Saponification by Potentiometric Titration. The standard for Neutralization Value by Color-Indicator Titration (D 974) is being given detailed review in an attempt to improve its precision and applicability.

Precipitation number of lubricating oils (D 91) is also receiving attention in order to improve its precision. The use of a pear-shaped centrifuge tube and pure hydrocarbon solvents are being considered as a means of accomplishing this objective.

The carbon residue Methods E 524 (Ramsbottom) and D 189 (Conradson) have been the subject of renewed interest. Consideration is being given to improvements in the Ramsbottom method that will avoid loss of sample when relatively volatile materials are tested.

A rapid carbon residue method is being evaluated. Improvements in the Conradson method will be reviewed in the hope that they will make the method more applicable to nonuniform samples.

Technical Committee G on Lubricating Grease *J. M. Bryant, Chairman*

The committee developed three new tentative methods which were accepted by the Society in June:

1. Cone Penetration of Lubricating Grease, Using a One-Quarter Scale Cone (D 1403),
2. Effect of Copper on the Oxidation Rate of Grease (D 1402), and
3. Estimation of Deleterious Particles in Lubricating Grease (D 1404).

A broad program to provide a series of chemical, physical, and functional tests for greases is continuing.

Subgroups have been appointed to develop information and revisions necessary to make Method D 128, Analysis of Grease, applicable to greases containing ester-type fluids, silicone fluids, nonsoap thickeners, and 12-hydroxy stearic acid.

A set of standard copper strips for use with Method D 1261, Effect of Grease on Copper, are being considered.

Method D 1092, Apparent Viscosity of Lubricating Grease, is receiving attention in a program designed to extend its range to temperatures as low as −65 F. Results are sufficiently encouraging to warrant continuation of the program.

Data on correlation of the new Quarter-Scale Cone Method (D 1403) and the older Method of Cone Penetration, (D 217), have been requested from members of the committee. Further work will be done with the "universal cone" to include all consistency grades up to NLGI No. 6. It is expected that the program will establish the precision of the higher consistency grades and permit suitable revision of Method D 217.

High-temperature bearing tests and low-temperature torque tests are included in the program of functional evaluation of greases. A functional life test for ball-bearing greases and a low-temperature torque procedure were published for information in 1956. Improvements and refinements of both tests will be reviewed prior to their recommendation for publication as tentatives.

Development of a suitable ASTM test for oil separation from grease is in progress. The causes of variables in test results are being evaluated.

Liaison is being maintained with the Coordinating Lubricant and Equipment Research Committee of Coordinating Research Council, Inc., concerning work on aircraft greases.

The committee has expressed an interest in a symposium on the extreme-pressure properties of lubricating oils. The symposium is being considered by Technical Committee B on Lubricating Oils.

Technical Committee C on Turbine Oils *G. V. Browning, Chairman*

The work of the committee resulted in the publication of a proposed method as information, Short-Term Oxidation Test for Turbine Oils. The proposed method represents the results of several years of work aimed at providing an oxidation test for turbine oils applicable for control testing but not as time consuming as Standard Method D 943.

A new tentative for emulsion testing of steam turbine oils (D 1401) was issued replacing the venerable Method D 157, Steam Emulsion of Lubricating Oils.

The committee organized and sponsored an ASTM Symposium on Steam Turbine Oils which was held in Los Angeles in September, 1956.

In cooperation with the ASME the committee is preparing recommended practices for the design of marine turbine lubricating systems. Turbines under 2000-kw capacity will be discussed.

In addition, recommendations on the design of industrial and mechanical drive of turbine lubricating systems are being developed.

Work on load-carrying capacity of turbine oils may be reactivated.

Technical Committee K on Cutting Fluids *R. F. McKibben, Chairman*

The committee has been reorganized into six sections which combine the functions of previous sections, subsections, and study groups. The sections are: I on Analytical Tests, II on Plant Evaluation, III on Definitions and Designations, IV on Flank Wear and Finish, V on Extreme Pressure Tests, and VI on Physical Tests. The group is continuing its program to develop full-scale and laboratory procedures to measure the effectiveness of cutting fluids and their constituents.

Technical Committee N on Hydraulic Fluids *H. F. King, Chairman*

This newest technical committee in Committee D-2 began work in February, 1956, on a program encompassing "specifications, methods of test, and nomenclature for hydraulic fluids."

The program is in its initial stages and the group has not been active long enough to make any recommendations. Nine sections have been established: I on Aircraft Applications, II on Industrial Applications, III on Marine Applications, IV on Mobile Applications, V on Applicability of ASTM Methods, VI on Fire Resistance, VII on Lubricating Properties, VIII on Stability, and IX on Compatability.

The diversity of the sections indicates the extent of the program which is expected to yield useful results in the near future.

Research Division IX on Color *H. M. Hancock, Chairman*

The Division has continued to improve and evaluate the proposed method for measuring the color of petroleum products, published as information in 1955 and republished in the 1956 Report of Committee D-2. The proposed method has been offered as a possible replacement for the ASTM Union Colorimeter Method, D 155.

The color standards prescribed in the proposed method are being evaluated by the Division to establish their acceptability, and a cooperative program using the color method has been instituted by the laboratories of the members of the Division and others interested. It is planned to recommend the publication of the new method as a tentative, if analysis of the cooperative program justifies this action.

The Subcommittee on Extreme-Pressure Properties Measurement *P. A. Asseff, Chairman*

As a supplement to the report that appeared in the April, 1952, ASTM BULLETIN, the subcommittee submitted additional data on the "Measurement of Extreme Pressure Properties of Lubricants," which was published in the ASTM BULLETIN, September, 1956, p. 25. This later report summarizes the cooperative work designed to provide liquid standards for calibration of the Timken extreme-pressure tester. Included are data on extreme-pressure measurements in the Timken tester on lubricating greases.

A proposed method of test for extreme-pressure measurements of petroleum products using the Timken machine will be offered for publication as information in the 1957 Report of Committee D-2.

A cooperative program will be organized that will use a test procedure employing the Shell four-ball extreme-pressure tester.

Research Division XII on Graphite Tests *H. J. Dawe, Chairman*

Definitions related to graphite are expected to be submitted to the Society in 1957 for publication as tentative.

Other new tentatives for graphite may include a method of test for ash and moisture, and a basic sampling method.

If the reproducibility of a proposed method of test for sieve analysis of graphites can be improved, it will be offered for publication as tentative.

Other Products

In addition to fuels and lubricants, Committee D-2 is interested in learning more about other important products such as petroleum wax, light hydrocarbons, petrolatums, and sulfonates. Some of the activity on these materials is given below:

Technical Committee H on Light Hydrocarbons *C. W Ricker, Jr., Chairman*

The committee believes that *STP 109*, "Physical Constants of Hydrocarbons Boiling Below 350 F," should be revised and continued as an ASTM publication because of its utility. Preparations for the revision are in progress.

The vapor pressure test for light hydrocarbons, Method D 1267, may be revised in 1957 in order to permit adjustment of minor equipment differences that exist between American and British apparatus. In addition, revisions may be proposed that will enable the conversion of vapor pressure at 100 F to vapor pressures at other temperatures.

Test methods applicable to pure hydrocarbons, such as ethylene, isobutane, isobutylene, isoprene, isopentane, and C_5-C_{10} olefins will be considered, as will volume measurement and correction tables for butadiene.

Progress has been made in the program to provide ASTM standards for gravity of, and corrosion by liquefied petroleum gas.

Technical Committee M on Petroleum Wax *G. G. Rumberger, Chairman*

This committee is a joint activity of ASTM and the Technical Association of the Pulp and Paper Industry (TAPPI). All of its eight sections are active on a program designed to provide test methods for physical, chemical, and functional qualities of wax and wax coatings.

Recent work has resulted in a revision of the standard method for determination of oil content (D 721), tensile strength (D 1320), and needle penetration tests (D 1321), and the publication as information of procedures for blocking point and oxidation stability of paraffin wax.

Revision of the standard for melting point (D 87) is being reviewed, and a new tentative for odor of petroleum wax will be proposed.

Emphasis will be given to the preparation of methods of test applicable to both paraffin and microcrystalline waxes. Methods for measurement of friction and staining qualities will receive attention.

A revision of the tensile strength method D 1320 will be offered which will specify a 2 per cent silicone oil instead of silicone grease as the mold release compound. Proposed revisions of Method D 1321 include a new needle and extension of the method to 100 penetration number.

Methods for oxidation stability and blocking point of wax have been the subject of further work. The method for blocking point is expected to be recommended as tentative this year.

Methods for sealing strength and for scuff are being developed. A method for gloss will be submitted for publication as information.

Subcommittees I on Pharmaceutical Petrolatums, XXIV on Tests for Petroleum Sulfonates, C. F. W. Gebelein, Chairman.—Method D 855, Analysis of Oil-Soluble Petroleum Sulfonates, was revised, as was Method D 1216, Analysis of Calcium and Barium Petroleum Sulfonates to clarify the sections on "Precision." Both methods were adopted as standard in 1956.

Measurement and Sampling

Research Division II on Measurement and Sampling *C. A. Neusbaum, Chairman*

The division has continued its program designed to improve existing standards and tables used in the measurement and sampling of petroleum and its products and to develop new test methods and tables as the need develops.

The activity during the past year resulted in the publication of new tentatives for calibrating barge tanks (D 1407), stationary horizontal tanks (D 1410), tank car tanks (D 1409), spherical and spheroidal tanks (D 1408), and liquid calibration of tanks (D 1406). These supplement the methods for calibrating upright tanks (D 1220) previously published and revised in 1956.

Present activity can be evaluated by reviewing procedures or revisions "published as information" in 1956. Although this material has no official status, it provides an indication of what may be recommended for ASTM standardization in a year or two. Included are:

(1) Proposed revisions of the gaging Methods D 1085, to include automatic gaging devices, and procedure for gaging tanks containing plastic foam blankets, (2) Proposed high and low-temperature extensions of gravity and volume correction tables.

The extensions of the volume and gravity correction tables are part of an extensive program to review and, if necessary, augment the existing ASTM Standard D 1250 (IP 200), ASTM-IP Petroleum Measurement Tables. Under consideration and discussion are gravity and volume correction tables for petrochemicals (in cooperation with Committee D-16 on Industrial Aromatic Hydrocarbons), asphalt, and liquefied petroleum gas.

A supplement to Standard D 1250 may be prepared which will contain an annual summary of additions and changes made or proposed in the standard.

The precision of the API gravity method (D 287) is being reviewed. Methods for the determination of specific gravity of liquefied petroleum gas are receiving attention. The work is being coordinated with Technical Committee H.

Papers presented at the February, 1956, Symposium on Automatic Sampling Devices were published in the April 1956 issue of *Oil and Gas Journal*, under the title, "Don't Sell Sampling Short." Pipeline sampling and the preparation of recommended practices on the design and operation of automatic sampling devices are the subject of future work.

Analytical Methods

Two large and active Research Divisions are engaged in a program to provide methods of test to analyze quantitatively and qualitatively the constituents of petroleum products and lubricants. The scope of this work covers chemical elements present in petroleum products as additives or contaminants and the analysis of petroleum fractions for hydrocarbon type. Included are related tools such as spectrographic analysis, density and refractive index determinations, and chromatography.

Research Division III on Elemental Analysis *C. M. Gambrill, Chairman*

The methods for sulfur, D 90 and D 1266, are being reviewed to determine their precision limits and may be combined into a single procedure. A rapid high-temperature method was published as information. Procedures for determining traces of sulfur in hydrocarbons will receive attention.

A study will be made to determine whether Method D 1091, phosphorus in lubricating oil and additives, should be revised to permit application to products containing over 2 per cent phosphorus.

A program is in progress to provide methods for the direct determination of barium, calcium, and zinc in lubricating oil and additives. The program includes polarographic methods for zinc and flame photometric procedures for barium and calcium. Completion of at least part of the work to the point of publication as information is expected.

A program will be organized to develop a method of test for vanadium in Navy special fuel oil. Work is also under way on a direct atomization procedure for sodium by flame photometry which, if completed, may be proposed as a replacement for the present flame photometer method, D 1318.

The existing methods for tetraethyllead—chemical (D 526) and polarographic (D 1269)—were revised. A rapid polarographic method was published as information. Other rapid tetraethyllead methods, such as the versene method, are being evaluated. Methods of greater precision will be reviewed and a decision made as to whether cooperative work should begin on the development of other instrumental methods for tetraethyllead, such as flame photometry or X-ray fluorescence.

Results are now available on the study to develop tests for wear metals in used diesel engine crankcase oils. The material has been published in a special booklet entitled, "Suggested Methods for Spectrochemical Analysis of Used Diesel Lubricating Oils." This reprint is available from Society Headquarters at $1 per copy. This information was presented, along with other papers, at the ASTM Symposium on Lubricating Oils, held in September in Los Angeles. R. L. LeTourneau was chairman of the group which developed the program presented as a joint activity of the division and Technical Committee B on Lubricating Oils.

Research Division IV on Hydrocarbon Analysis *W. E. Scovill, Chairman*

The improvement in petroleum products has necessitated a corresponding improvement in the test methods used in evaluating them. The program of the division includes the determination of hydrocarbon types by a number of approaches: olefins and aromatics by bromine number and acid treating; hydrocarbon types by chromatography, spectroscopy, and refractive index; purity of hydrocarbons by freezing point; and other methods for qualitative evaluation such as aniline point and correlation techniques. Gas chromatography is the newest tool to be added to the list of approaches, and an active program using this tool is being developed.

A comparison of many of these various methods is being made on seven types of samples, including gasolines, kerosines, and jet fuels. It is hoped that data will be obtained on their behavior and variation with the different characteristics of the samples, as well as information on their limitations and precision.

The method for olefinic and aromatic hydrocarbons, D 1019, was revised to improve the procedure for centrifuging.

The relationship between olefin structure and bromine number as determined by Methods D 1158 and D 1159 is being studied in order to extend the application of the methods and improve their precision. The method for hydrocarbon types by fluorescent indicator adsorption (D 1319) was revised in order to clearly specify the type of silica gel to be used and to provide procedure that will reduce loss of volatile constituents of the test sample. Improvements in the method's precision are being reviewed.

Procedures for density, refractive index, and refractive dispersion at high temperatures are being studied. Methods for density of viscous liquids and melted solids were published as information in 1956. A program was started on the determination of refractive index at high temperatures which includes a revised procedure, specially prepared unknown samples, and the use of pure hydrocarbons as reference standards.

Spectroscopic work includes broadening the scope of the proposed method for benzene, toluene, ethylbenzene, and individual xylenes. Steps are being taken to obtain mixtures of paraffins, cycloparaffins, and aromatics for use as standards in calibrating spectroscopic instruments.

The aniline point Method D 611, was revised to avoid difficulties caused by excess humidity when the test is performed.

Work on correlative methods includes development of a standard paraffin-naphthene chart based on refractive intercept and density measurements, and a method for molecular weight correlations.

The composition of jet fuels will be evaluated in order to determine which constituents cause poor combustion characteristics in jet engines. The work will be done in cooperation with Technical Committee J on Aviation Fuels.

Although the work of the Division has centered on the development of methods for hydrocarbon type for products which boil below 600 F—such as gasoline, naphtha, kerosine, jet fuel, and most burner and diesel fuels—techniques and methods for determination of higher boiling products have resulted in a decision to review them by staging a symposium.

The Symposium on Composition of Petroleum Oils, Determination and Evaluation, was held on Feb. 8 and 9, 1957, in New Orleans. Fifteen papers written by recognized authorities were presented, followed by an open discussion in which H. M. Smith, chairman of Committee D-2, served as moderator. It is the hope of the Division that the symposium may serve as a starting point for a program of standardization of methods for hydrocarbon type for petroleum fractions boiling above 600 F.

The papers presented at the symposium will be printed and published by the Society as a *Special Technical Publication*. The American Petroleum Institute jointly sponsored the session and the program was developed by R. A. Klett, H. M. Smith, W. E. Scovill, and R. L. LeTourneau.

THE PROVISIONAL PROGRAM

of the 60th Annual Meeting

Atlantic City, June 16–21

will appear in the

APRIL BULLETIN

Building Code for Plastics Proposed

In June, 1956, one of the newer classes of building materials—plastics—received an important assist toward wider acceptance in building codes with the joint publication by the Society of the Plastics Industry and the Manufacturing Chemists Assn. of a Model Chapter on Plastics for Inclusion in a Building Code. This Chapter is in the form of a recommendation as a proposed amendment to local building codes and it represents an effort by the plastics industry to assist building officials by furnishing information and appropriate regulations to permit the use of plastics material in building construction. The Chapter defines plastic materials as those made wholly or principally from standardized plastics listed and described in the current edition of "Technical Data on Plastics," published by the Manufacturing Chemists Assn. Four classes of plastic materials are described, based on degree of flammability or amount of noncombustible material contained in the plastic composition.

Reference is made to the following ASTM standards:

Method of Test for Flammability of Plastics Over 0.050 in. in Thickness (D 635 – 44)
Method of Test for Flammability of Plastics 0.050 in. and Under in Thickness (D 568 – 43)
Method of Test for Heat Distortion Temperature of Plastics (Tentative) (D 648 – 45 T)
Methods of Test for Thickness of Solid Electrical Insulation (D 374 – 42)

Copies of the Model Chapter on Plastics are available from the Society of the Plastics Industry, Inc., 250 Park Ave., New York 17, N. Y.

All Fouled up!
First Prize, General Photographs—Tenth ASTM Photographic Exhibit. Edmund F. Hawes, Universal Oil Products Co., Des Plaines, Ill.

Proposed Method of Test for Defining Noncombustibility of Building Materials

(Published as Information Only)

EDITOR'S NOTE—The terms "combustible" and "noncombustible" cannot be defined by the ordinary dictionary. Iron is combustible under limited conditions in an atmosphere of oxygen and combustions of many other materials can be established by the physical scientist, whereas these materials in normal use would be considered to be noncombustible. In the field of building materials are many materials that in their simple elementary form are accepted by all as being noncombustible. Among these are gypsum, pure asbestos, uncoated steel, water, etc., but there are other generally elemental materials which by their nature contain very small amounts of combustible materials and are therefore in the main, borderline cases. A line must be drawn so that if more or less elemental material successfully passes the test it will not aid combustion or add appreciably to an ambient fire. When a specification calls for all parts of a building fabrication to be of noncombustible materials there must be some criterion by which differences of opinion may be settled. This test method is intended to serve this purpose.

Committee E-5 on Methods of Fire Tests has been interested in the defining of the terms "combustible" and "noncombustible" for a number of years. Subcommittee V on Nomenclature and Definitions, J. R. Shank, Chairman, has submitted this method to be published as information only. It is hoped that this publication will contribute to a better understanding of this classification of materials.

Scope

1. The test is designed to provide a method for determining *noncombustibility* of elementary materials of which building materials are composed, to indicate those materials which do not act to aid combustion or add appreciable heat to an ambient fire. It is not intended to apply to laminated or coated materials.

Definition

2. A material shall be classed as *noncombustible* if it meets the requirements of the test procedure described in these methods.

Apparatus

3. (*a*) The equipment shown in Fig. 1 consists primarily of two 10-in. long, concentric, refractory tubes 3 and 4 in. in inside diameter, with axes vertical, and with heat applied by electric heating coils outside of the larger tube. A controlled flow of air is admitted tangentially near the top of the annular space between the tubes which passes to the bottom of the inner tube. The outer tube rests on a refractory bottom and the inner on three spacer blocks so as to afford a total opening under the inner tube equal to or greater than that of the annular space. The refractory bottom plate has a removable plug for cleaning. A transparent cover of heat-resisting glass or other transparent material is provided over the top of the inner tube with a 1-in. square opening over the axis of the tubes. This cover may be in two movable parts.

(*b*) Thermocouples or other temperature-measuring devices, preferably automatically recording, are provided, one for the air in the lower part of the inner tube, another on the specimen in the approximate center of the space, and a third within the interior of the specimen. A fourth thermocouple may be provided, if desired, in the region of the heating coils for better regulating the temperature of the air in the furnace space.

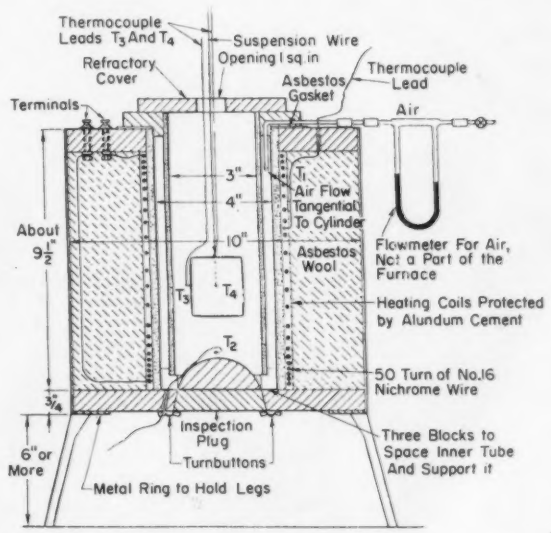


Fig. 1—Section Through Furnace.

Test Specimens

4. (*a*) All test specimens shall be 1.5 in. wide by 1.5 in. thick in cross-section perpendicular to the air flow in the furnace and 2.0 in. long, with tolerances on the dimensions of ±0.1 in. The specimens shall be dried at 140 ± 5 F for not less than 24 nor more than 48 hr before being tested.

(*b*) Specimens in granular or powder form may be contained in thin-wall, open-top vessels of inert materials whose outside dimensions conform to the specimen shape and maximum size specified in paragraph (*a*). These vessels may have solid walls or be of mesh.

(*c*) Not less than four identical specimens shall be tested to determine values.

Procedure

5. (*a*) Prepare the furnace by bringing the temperature T_2 (in the tube under the specimen, see Fig. 1) of the air in the furnace tube to 1382 ± 10 F, maintaining the furnace setting long enough to ascertain that it will remain at constant temperature in the unloaded furnace for at least 15 min while air passes at a velocity of 10 ft per min ± 20 per cent past a loaded specimen in the tube, computed on the basis of air supply and velocity at room temperature and pressure.

(*b*) Insert the test specimen, with thermocouple T_3 attached to the side

surface of the specimen and thermocouple T_4 inserted from the top of the specimen to its approximate volumetric center, as rapidly as possible from above into the furnace. Close the top cover to the 1-sq in. opening immediately after insertion of the specimen. If readings are to be made manually, make them as often as possible, particularly for thermocouples T_3 and T_4 at intervals not less than once per minute for the first 5 min, and as often afterwards as necessary to produce a smooth curve. Do not change the regulation of the current through the heating coils and the air flow during the test.

(*c*) Continue the test until the temperatures at thermocouples T_3 and T_4 have reached maxima or until it is clearly evident that the specimen does not pass this test.

(*d*) Throughout the test make and record visual observations on the specimens, noting quality, quantity, or intensity and duration of flaming or smoking, or both, and change of state.

Interpretation of Results

6. Materials subjected to the test described in these methods shall be reported as noncombustible if the recorded temperatures of the surface or interior thermocouples do not at any time during the test rise to more than 54 F (30 C) above the furnace air temperature at the beginning of the test, or if there is no flaming of the specimen after the first 30 sec. The results for the four specimens tested shall be averaged.

FEDERAL GOVERNMENT STANDARDS

INDEX CHANGES

THE General Services Administration of the Federal Supply Service is charged with the responsibility for establishing specifications to be used by the Federal Government for procurement of materials and supplies. The GSA issues an annual Index to Initiation of Federal Specifications and Federal Standards Projects, and monthly supplements.

Items listed below appeared in Supplement No. 8 for the month of October, 1956.

INITIATIONS

Title	Type of Action	Symbol or Number	FSC Code	FSSC Class	Assigned Agency & Preparing Activity
Adhesive, Casein-Type, Water and Mold-Resistant	Am. 1	MMM-A-125	8040	..	DOD-Army-Ord.
Adhesive, Vinyl Acetate Resin Emulsion	Rev.	MMM-00193	8040	..	AGR-FS
Belting, Flat, Leather, Vegetable-Tanned	Am. 1	KK-B-201c	3030	30	COM-NBS
Bolts (Square Neck, Machine, Ribbed Neck) Finned Neck, Tee Head, (Key Head) (Round Neck)	New	FF-B-00584	5306	..	COM-NBS
Boxes, Wood Nailed and Lock Corner	..	...	..	..	...
Bronze, Aluminum; Rods, Bars, Shapes, and Forgings	Am. 1	PPP-B-621	8115	..	DOD
Bronze; Castings	Rev.	QQ-B-663	9530 9540	..	DOD-Ord.
Leaded Tin Bronze Castings and High Leaded Tin Bronze Castings	Rev. New	QQ-B-691b QQ-L-225	9530	..	DOD
Plastics; Polystyrene Molding Material	New	Fed.Std.113	9330	..	DOD-Ord.
Soap, Toilet (Floating, White)	New	P-S-616b	8520	51	COM-NBS
Steel Bars and Forgings, Graphitic	Rev.	QQ-S-628	9510	..	GSA-FSS
Tape, Pressure-Sensitive Adhesive Filament Reinforced	Am. 3	QQ-S-628	9510	..	DOD-Navy-Ships
Tape, Pressure Sensitive Adhesive, Paper, Water Resistant	Rev. New	PPP-T-97 & PPP-T-0097 (GSA-FSS)	8135	..	GSA-FSS
Tape Pressure Sensitive Adhesive, Waterproof for Packaging and Sealing	Am. 1	PPP-T-76	8135	..	DOD-Army-QMC
	Am. 1	PPP-T-60	8135	..	GPO

REASSIGNED PROJECTS

Wire, Steel, Carbon, Round, Bare and coated	Bare Rev.	QQ-W-461b	DOD-Navy-Ord GSA-FSS

CANCELLATIONS

Title	Symbol or Number	Reason for Cancellation
Magnesia, Block Cement, and Pipe-Covering (Molded)	HH-M-61a	Superseded by Fed. Spec. HH-I-554
Wiping Cloths, Cotton	DDD-W-415a	Superseded by Fed. Spec. DDD-R-30

PROMULGATIONS

Title	Type of Action	Symbol or Number
Aluminum Alloy Bars, Rods, and Wire (Rolled or Drawn) 2017 (Superseding Fed. Spec. QQ-A-351c)	Rev.	QQ-A-351d
Boxes, Fiberboard, Wood-Cleated (Superseding Int. Fed. Spec. PPP-B-00591 (Army-QMC) and Fed. Spec. NN-B-591a)	New	PPP-B-591
Cadmium Red (Cadmium Lithopone) Dry Paint Pigment	New	TT-C-80
Cleaning Compound, Platers' Electrocleaning, for Steel	Am. 1	P-C-535
Cloth, Cotton, Sheeting (Superseding Int. Fed. Specs. CCC-C-00430 (DOD-Ships), CCC-S-00271a(GSA-FSS) and Fed. Specs. CC-S-271a, CCC-S-291a	New	
Containers, Folding, Corrugated, Fiberboard (For Household Goods) (Superseding Int. Fed. Spec. PPP-C-00570 (Army-CE)	New	PPP-C-570
Insulation, Thermal (Vermiculite) (Superseding Int. Fed. Spec. HH-I-00585)	New	HH-I-585
Laminated Thermosetting Sheets, Rods, and Tubes	Am. 1	L-L-31
Leather, Cattlehide, Upholstery (Superseding Int. Fed. Spec. KK-L-291d (COM-NBS) and Fed. Spec. KK-L- 291c)	Rev.	KK-L-291d
Packaging, Packing and Marking of Textile Fabrics (Woolens, Worsteds, Cottons, Silks and Synthetics) (Superseding Int. Fed. Spec. PPP-P-0051(NAVY-S&A)	New	PPP-P-51
Paint, Phosphorescent, Ready-Mixed (Non-Radioactive) (Superseding Int. Fed. Spec. TT-P-0054a (COM-NBS) and Fed. Spec. TT-P-54)	Rev.	TT-P-54a
Plastic, Methacrylate; Sheets, Rods, and Tubes-Cast (Superseding Fed. Spec. L-M-191)	New	L-P-391
Rope, Manila and Sisel (Superseding Fed. Spec. T-R-631 and Fed. Spec. T-R-601a)	New	T-R-605
Sheet, Bed; Cotton (Bleached)	Am. 1	DDD-S-281c
Tape; Pressure Sensitive Adhesive, Waterproof—For Packaging and Sealing	Am. 1	PPP-T-60
Tinplate (Hot Dip and Electrolytic) (Superseding Fed. Spec. QQ-1-706a)	New	QQ-T-425

INTERIM FEDERAL SPECIFICATIONS and STANDARDS ISSUED

Title	Type of Action	Symbol or Number
Soap, Toilet (Floating, White)	New	P-S-00616c(GSA-FSS)
Tape: Pressure-Sensitive Adhesive; Vinyl Plastic Film	Rev. 2	PPP-T-0066(GSA-FSS)
Plastics: Polystyrene Molding Material	New	Int. Fed. Std. No. 00113
Preservation, Packaging, and Packing Materials; Test Procedures	New	Int. Fed. Std. No. 00101 (NAVY-AFL)

SPECIFICATIONS and STANDARDS APPROVED FOR PRINTING

Title	Type of Action	Symbol or Number
Paper, Bond and Writing, White and Colored	Rev.	Fed. Std. No. 53a
Adhesive, Polyvinyl Acetate Resin Emulsion (Alkali Dispersible)	New	MMM-A-180
Colors; (For) Ready-Mixed Paints	Canc.	TT-C-595
Methacrylate Plastic Sheets, Rods and Tubes	Canc.	L-M-191
Rope, Manila	Canc.	T-R-601a
Rope, Sisal	Canc.	T-R-631
Sheeting; Cotton, Bleached, Wide	Canc.	CCC-S-271a
Sheeting, Cotton, Unbleached, Wide	Canc.	CCC-S-219a

Proposed Method of Test for Calcium and Magnesium Oxides in Lime

EDITOR'S NOTE.— Committee C-7 on Lime has been interested in the development of a rapid method for determining calcium and magnesium oxides in lime to be used for routine control analysis. Subcommittee V on Methods of Test of Lime and Lime Products, D. G. Hamme, Chairman, has submitted this method to be published as information only. It is hoped by this publication that broader use of the method may be accomplished and comments secured for further consideration of the subcommittee. This method appeared in December issue of the BULLETIN. Certain changes of significance indicated the desirability of republishing the method, since it was otherwise misleading.

Scope

1. This method covers a volumetric procedure for routine control analysis for calcium and magnesium oxides in lime, limestone, or dolomite.

Principle of Method

2. The method is based on the principle that, at pH 10, the wine-red colored magnesium chelate of the dye, Chrome Black T, color index 203, is less stable than the magnesium chelate of sodium ethylenediamine tetraacetate. Thus, the dye color, originally wine-red in the presence of magnesium ion, suddenly changes to blue at the end point when the chelation of magnesium with sodium ethylenediamine tetraacetate is complete.

Interfering Elements

3. (*a*) Barium and strontium in moderate amounts do not affect the titration results for calcium. However, in the titration for total hardness both barium and strontium titrate before magnesium and therefore results for magnesium oxide (MgO) will be high by an amount equivalent to the barium and strontium present. The addition of 3 to 4 ml of saturated potassium sulfate solution before titrating for magnesium appears to practically eliminate the interference of barium and strontium.

(*b*) Copper and manganese in excess of 10 ppm interfere but are not normally present in sufficient quantity to affect results.

(*c*) Samples that are high in iron and aluminum oxides (R_2O_3) or magnesium, or both, form precipitates of hydroxides at the pH necessary for the complete chelation of calcium ions. Precipitating R_2O_3 by adjusting the pH to 5 to 6 and allowing the precipitate to settle before removing aliquot for titration has not been beneficial. In the case of magnesium, the precipitate dissolves as the end point is reached. With high R_2O_3 content the precipitate does not dissolve, but with continued stirring it becomes finely dispersed and does not interfere with the end point to any appreciable extent.

Interfering Minerals

4. Samples containing mica yield low results for magnesium oxide (MgO) when treated as Section 7. Excellent results are obtained by filtering the hydrochloric acid solution of the sample, fusing the residue with 1 g of anhydrous sodium carbonate, and dissolving the fusion in the acid filtrate before diluting to volume in the 1-liter volumetric flask. Make carbonate fusions with all samples from unknown sources by the fusion method if they carry an excessive amount of silica (SiO_2) plus other insoluble materials.

Purity of Reagents

5. (*a*) Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.[1] Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

(*b*) Unless otherwise indicated, reference to water shall be understood to mean distilled water.

Reagents

6. (*a*) *Calcium Chloride, Standard Solution (1 ml. ≡ 0.00028 g CaO).*—Dry $CaCO_3$ for 2 hr at 110 C in a weighing bottle. Stopper and cool in a desiccator. Transfer a 0.5000-g portion to a 250-ml beaker, wet with water, cover, and slowly add 3 ml of HCl. Boil a few minutes, cool, and transfer to a 1-liter volumetric flask. Dilute to 1 liter and mix thoroughly.

(*b*) *Calcium Indicator Solution.*—Grind together 0.2000 g of ammonium purpurate and 40 g of sodium chloride (NaCl) with a mortar and pestle.

(*c*) *Hardness Buffer Solution.*—Weigh 33 g of ammonium chloride (NH_4Cl) into a 400-ml beaker and dissolve in approximately 150 ml of water. Transfer to a 500-ml volumetric flask and add 280 ml of NH_4OH (sp gr 0.90). Dilute to the mark with cold water and mix.

(*d*) *Hardness Indicator Solution.*—Dissolve 0.5 g of Chrome Black T, color index 203[2] (1-(1-hydroxy-2-naphthylazo)-5-nitro-2-naphthol-4-sulfonic acid sodium salt) and 4.5 g of hydroxylamine hydrochloride in 100 ml of alcohol. Store in a glass-stoppered bottle. This solution is stable for at least two months.

(*e*) *Hydrochloric Acid (sp gr 1.19).*—Concentrated hydrochloric acid (HCl).

(*f*) *Magnesium Chloride Solution (2 g per liter).*—Dissolve 2.0 g of $MgCl_2$ in water. Add 2 ml of HCl and dilute to 1 liter.

(*g*) *Potassium Hydroxide Solution (200 g per liter).*—Dissolve 40 g of KOH pellets in water and dilute to 200 ml.

(*h*) *Sodium Ethylenediamine Tetraacetate, Standard Solution.*—Dissolve 3.7500 g of disodium ethylenediamine tetraacetate dihydrate in 400 to 500 ml of water containing 0.5 g of sodium hydroxide (NaOH). Transfer to a 1-liter volumetric flask and dilute to 1 liter. Standardize as follows: Measure 25.00 ml of calcium chloride ($CaCl_2$) solution (1 ml = 0.0005 g) from a buret into a 210-ml casserole at a rate not to exceed 10 ml per min. Add 10 ml of water, 1 ml of KOH solution and 150 mg of calcium indicator and continue as directed in Section 7(*c*). (Note 1.)

Titrate three 25-ml aliquots and take the average value of the three titrations, which should not vary by more than 0.02 ml. The disodium ethylenediamine tetraacetate solution should be protected from air and restandardized against the standard $CaCl_2$ solution at

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] "Reagent Chemicals, American Chemical Society Specifications," Am. Chem. Soc., Washington, D. C. For suggestions on the testing of reagents not listed by the American Chemical Society, see "Reagent Chemicals and Standards," by Joseph Rosin, D. Van Nostrand Co., Inc., New York, N. Y., and the "United States Pharmacopoeia."

[2] Eriochrome Black T, manufactured by Geigy Co., Inc., New York, N. Y.; Omega Chrome Black S, manufactured by Sandoz Chemical Works, Inc., New York, N. Y.; Pontachrome Black TA, manufactured by E. I. du Pont de Nemours & Co., Wilmington, Del.; and Eriochrome Black T, Catalogue No. P6361, Eastman Kodak Co., Rochester, N. Y., are satisfactory for this purpose.

least once a month. Calculate the magnesia (MgO) equivalent as follows:

$$\text{CaO equivalent} = (A/B) \times 100$$

$$\text{MgO equivalent} = 0.7191 \times \text{CaO equivalent}$$

where:

A = CaO equivalent of 25.00 ml of the standard $CaCl_2$ solution, and

B = milliliters of sodium ethylenediamine tetraacetate solution required for titration of the $CaCl_2$ solution.

NOTE 1.—The titration of the standard $CaCl_2$ solution with the standard ethylenediamine tetraacetate solution for total hardness should yield the same values as those obtained in the CaO titration. To check this, measure 25 ml of water into a clean casserole, add 2 ml of hardness buffer solution and 5 to 6 ml of the $MgCl_2$ solution. Now add 3 to 4 drops of hardness indicator solution and titrate with standard ethylenediamine tetraacetate to change from wine-red to a pure blue end point. Add the ethylenediamine tetraacetate slowly and allow a few moments time between each drop when nearing the end point. "Split" a drop if necessary to avoid overreaching the end point. Now measure exactly 25 ml of the standard $CaCl_2$ solution into the contents of the casserole and titrate again to the blue end point as outlined above. Another drop or two of indicator may be added just before the end point is reached, if the color of the solution has faded. The volume of ethylenediamine tetraacetate solution required for the last titration should be the same as that required for the CaO titration; if not, check the water and all reagents for magnesium and determine a blank correction factor.

Procedure

7. (*a*) Weigh 0.5000 g of the sample into a 250-ml beaker and wet with 10 ml of water. Cover with a watch glass and slowly add 5 ml of HCl. Keep covered and boil down to 3 to 4 ml volume to decompose the sample and to expel excess acid. Dilute with water to 50 to 60 ml and boil 5 min longer. Cool and transfer to a 1-liter volumetric flask. Dilute to the mark with cool water and mix thoroughly.

(*b*) Drain the buret used for standardizing the standard $CaCl_2$ solution and rinse twice by filling with the sample solution and draining. Refill the buret with the sample solution.

(*c*) *Titration for Calcium.*—Measure 25.00 ml of the sample solution into a casserole. Add 10 ml of water, 1 ml of KOH solution, and 150 mg of calcium indicator. Stir and titrate with standard sodium ethylenediamine tetraacetate solution. Add the solution only 1 drop at a time as the color starts to change from pink to orchid, stirring after each addition and noting color change. Read the buret to the nearest 0.01 ml between each addition; when the final drop shows no further change in color, consider the end point as being the previous reading (Note 2).

NOTE 2.—If in doubt about the end point, check until two results are obtained that agree within 0.02 ml and take the average.

(*d*) *Titration for Calcium Plus Magnesium* ("*Total Hardness*").—Measure from the buret (Paragraph (*b*)) 25.00 ml of the sample solution into a casserole. Add 25 ml of water and 2 ml of hardness buffer solution. Titrate with standard sodium ethylenediamine tetraacetate solution until within 0.1 to 0.2 ml of the volume expected to be required to reach the end point (Note 3). Add 1 to 2 drops of hardness indicator solution, which should produce a wine-red color in the solution. Continue the titration until the last drop changes the color to pure blue.

NOTE 3.—For this titration it is desirable to add the indicator just prior to reaching the end point. This can be accomplished by titrating one 25.00-ml aliquot to which the indicator has been added in order to establish the approximate end point before the titration for the exact end point is made.

Calculations

8. Calculate the percentages of CaO and MgO as follows:

$$A = C \times D$$

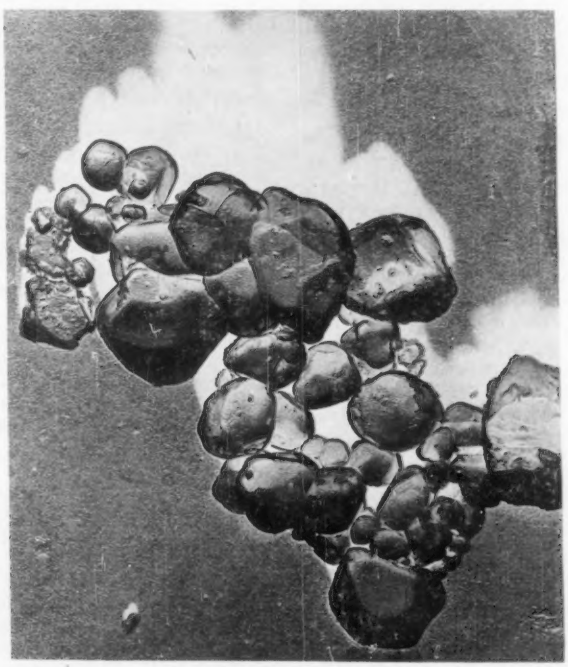
$$B = (E - C)\, D \times 0.7191$$

where:

C = milliliters of standard sodium ethylenediamine tetraacetate solution added in titrating for calcium,

D = CaO equivalent of the ethylenediamine tetraacetate solution, and

E = milliliters of standard sodium ethylenediamine tetraacetate solution added in titrating for calcium plus magnesium.



Carbon Replica of Calcined Zinc Sulphide Particles—Electron Micrographs (× 80,000). (Reduced for publication).

First Prize, Foreign Electron Micrographs—Tenth ASTM Photographic Exhibit. John Marriott, Imperial Smelting Corp., Ltd., Avonmouth, England.

The surface structure of pigment particles is of interest where oil absorption and degree of aggregation are important factors. This micrograph shows a preshadowed carbon replica of a cluster of calcined zinc sulfide particles revealing the tendency to form crystal faces and the relatively smooth surfaces characteristic of calcined material.

New Data on Stress-Corrosion Cracking of Brass

STRESS-CORROSION cracking has been a problem in the production of wrought-brass articles for many years. During spinning or deep drawing of brass cups, lamp bases, and the like, stresses are set up which remain in the metal unless removed by annealing. Then, if the brass is stored in an atmosphere containing small amounts of ammonia and water vapor, stress-corrosion cracking may occur. Even very small amounts of ammonia, such as are found in the average home atmosphere, may be sufficient to cause this effect. Industrial atmospheres are likely to be even more corrosive.

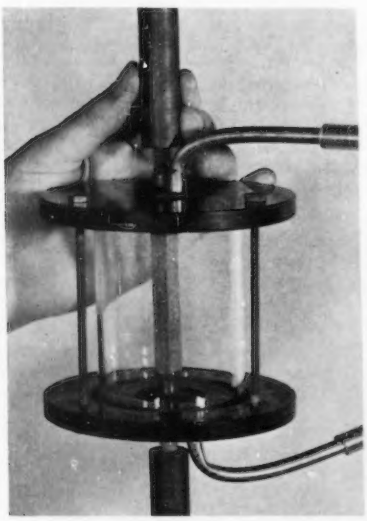


Fig. 1.—Brass Specimen in Circulating-Atmosphere Cell for Study of Stress.

Although wide investigation has produced many explanations for the stress-corrosion mechanism in other metals, little is definitely known about the process as it occurs in brass. The action is generally considered galvanic, but its mechanism is not understood. Seeking to extend basic knowledge in this field the National Bureau of Standards recently made a study of the relationship between crystal orientation and stress-corrosion cracking in alpha and beta brasses.[1] Results indicate that crystal orientation has an important influence on the galvanic action which produces stress-corrosion cracking in brass.

The Bureau study included direct observation of test specimens. These were prepared with crystals large enough for visual inspection—$\frac{1}{8}$ in. or larger. Two compositions of alpha metal were studied: cartridge brass (70 per cent copper, 30 per cent zinc) and commercial bronze (90 per cent copper, 10 per cent zinc). The alpha phase is found in most fabricated articles, often with small grains of the beta phase (50 per cent copper, 50 per cent zinc) scattered through the matrix. The specimens were machined with square cross-sections and exposed to an atmosphere containing ammonia gas, carbon dioxide, water vapor, and air (Fig. 1). They were subjected to tensile stresses of 5000 to 6000 psi until stress-corrosion cracks appeared.

Cracks approximately normal to the length of the specimen, extending into

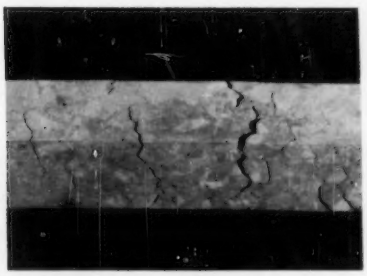


Fig. 2.—Part of a Specimen of Alpha Brass Containing Intercrystalline Stress-Corrosion Cracks.

adjacent faces from a corner (Fig. 2), were studied by X-ray diffraction techniques. It was found that the crystallographic planes bounding the cracks are randomly distributed so that cracking is not due to corrosion attack along particular crystal planes. The data also show that the stress-corrosion cracking of alpha brass is most probable at those crystal boundaries that have the highest energy because of relative orientation of the adjacent crystals. As the attack progresses at a particular grain boundary, points of stress concentration are localized and a suitably oriented stress pattern causes rupture of the protective film on the metal at the apex of the attack. Previous work has shown that film-free alpha brass is approximately $\frac{1}{2}$ v anodic to brass covered with an atmospherically formed film or with corrosion products.[2] Thus, a galvanic cell is set up with metal going into solution and forming the stress-corrosion crack at the anode. The attack will continue until a change in the stress pattern or other factors permit the protective film to reform at the anode.

Beta brass specimens were tested and studied in the same way. It has been reported that crystal boundary energy in beta brass is smaller than in alpha. Thus, there might be less chance that a crack would start at a specific crystal boundary in the beta alloys. Results of the tests support this idea. Most stress-corrosion cracks were transcrystalline. The data indicate that crystals containing stress-corrosion cracks were more favorably oriented for deformation under applied stress than randomly oriented crystals in, for example, an unused test specimen. Thus it is suggested that applied stress produces microscopic deformation in most favorably oriented crystals. Deformation then ruptures the protective film on the crystals and stress corrosion proceeds by the same process as that suggested for alpha brass.

Fig. 3—Typical Stress-Corrosion Cracks in a Brass Lamp Base.

Unless conditions permit film repair, stress-corrosion in both alpha and beta brasses may proceed to complete failure in a relatively short time (Fig. 3). If the film is restored and stresses are not increased or readjusted, stress corrosion may cease.

[1] For further information, see Relationship between Crystal Orientation and Stress-Corrosion Cracking in Alpha- and Beta-Brasses, by H. L. Logan, *Journal of Research*, Nat. Bureau of Standards, Vol. 56, p. 159 (*RP* 2662).

[2] For further technical details, see Film Rupture Mechanism of Stress-Corrosion, *Journal of Research*, Nat. Bureau of Standards, Vol. 48, p. 99 (1952) (*RP* 2291).

The Bookshelf

The Condensed Chemical Dictionary

Arthur and Elizabeth Rose, Reinhold Publishing Corp., New York, N. Y.; 5th Ed.; 1222 pp.; $12.50

THIS book provides a valuable reference for information on chemical compounds and substances and also on chemical terminology. Comprehensiveness of the coverage is indicated by the number of entries—30,000. Particularly expanded since the previous edition is the information on trade names. All entries continued from the previous edition have been revised wherever necessary.

In addition to the definitions of the item listed, much other helpful information properties, derivation, forms, and uses is included. Where significant, such additional information as containers, hazards, and shipping regulations is given.

Utility of the book is enhanced by an easily read format and the use of thumb-indexing.

M. D. H.

Modern Instruments in Chemical Analysis

F. M. Biffen and William Seaman, McGraw-Hill Book Co., New York, N. Y.; 330 pp.; $7.50.

THE 14 chapters of this book cover most of the important instruments currently in use for chemical analysis. The descriptions are elementary, and in general explanatory material is not at an advanced level. This volume would make an excellent textbook for an introductory class in instrumental analysis. The book could prove valuable to chemists not ordinarily concerned with analytical problems who might be interested in rounding out their knowledge.

About half the book is devoted to various forms of spectroscopy such as flame photometry, ultraviolet and infrared spectroscopy. Chapters are also devoted to X-ray diffraction, mass spectrometry, and Raman spectra work. The other half of the book concentrates on electroanalysis including chapters on potentiometric, conductometric, and coulometric methods. Short surveys are also made in polarography and radiochemical methods. One of the most valuable features of the book is a rather comprehensive coverage of commercially available instruments necessary for the various procedures.

Included in the book are descriptions for using the various instruments. However, there is little devoted to the interpretation of results, or to the mathematical background necessary for a complete understanding of either the instruments or results. Omitted from the book is any mention of the new instruments now becoming widely popular such as nuclear resonance apparatus, chromatographic, ultrasonic, and thermal conductivity instruments.

The book is well illustrated, contains many references and bibliographies, and has a comprehensive treatment of the applications for each of the instruments described.

A. L. B.

Bibliography of Solid Adsorbents, 1943–1953

Victor R. Deitz, National Bureau of Standards *Circular* 566, 1528 pages, $8.75 (Order from the Government Printing Office, Washington 25, D. C.)

THIS annotated bibliographical survey of the scientific literature covers the period from 1942 to 1953 and contains approximately twice as many references as are found in the Bibliography of Solid Adsorbents, 1900 to 1942. A complete author index and a comprehensive subject index are features of this circular. The utility of the subject indexing is contained in the main heading which is based on the type of adsorbent and the subheadings which cover some general aspects of the gas or solution phase.

The effects of adsorbents on particular gases, liquids, or solutions are of particular importance to the petroleum, sugar, biochemical, agricultural, mining, and metallurgical industries as well as in water purification. Since catalytic processes involve adsorption as an essential step, this bibliography is of especial value to those interested in catalysis.

The preparation of this volume was conducted as part of a program of research under the cooperative sponsorship of NBS and the Bone Char Research Project, Inc., a research associateship established at the Bureau in 1939. Copies of the first volume may be procured from the Bone Char Research Project, Inc., Revere Sugar Refinery, 333 Medford St., Charlestown 29, Mass. ($12 prepaid.)

Pig Lead of High Purity Transverse Section—as Cast (× 2). (Reduced for publication).

Second Prize, Micrographs—Tenth ASTM Photographic Exhibit. Oliver E. Olsen, National Lead Co., Brooklyn, N. Y.

Large grains are due to high purity of the lead (99.99 per cent). If an alloying element such as copper were added, in as small an amount as 0.04 per cent, the grains produced, under similar casting conditions, would be about one tenth as large. Etchant: ammonium molybdate reagent.

Use Specifications in Buying Rubber Parts*

By RAYMOND B. STRINGFIELD

Production troubles actually experienced could all have been avoided by use of proper specifications already developed by ASTM

Some thirty years ago the famous rubber chemist, Giuseppi Bruni of Milan, Italy, made a very wise observation. He said that the rubber industry was like a semipermeable membrane; a lot comes in from the outside but very little gets out from the inside. Unfortunately the observation still seems to be true. Regardless of our scientific or engineering training, very few of us have any idea of the technological problems involved in making a rubber article or of the wide range of properties available unless we have actually worked in the rubber industry, and this hampers the exchange of needed information when we wish to have rubber parts made for our own use. So it may be profitable to spend a few minutes talking about some rubber fundamentals and some examples of the problems which arise when we ignore them. Let us mention a few fundamentals first.

Rubber Fundamentals

The rubber hydrocarbon, whether it is natural rubber, GR-S, neoprene or one of the other synthetic elastomers, is merely the starting point for the rubber compound, and the finished compound usually contains only 25 to 70 per cent rubber. This rubber, however, is the main determinant of such things as oil or chemical resistance, heat build-up, permanent set, and the rate at which the physical properties change with temperature.

To the rubber hydrocarbon we add a multitude of compounding ingredients to obtain the physical properties desired; sulfur and zinc oxide for vulcanization, organic accelerators to speed up the vulcanization, antioxidants to give good aging resistance, plasticizers for softness, synthetic resins for stiffness, colors for beauty or identification, reinforcing fillers to increase tensile and tear, and inert fillers to reduce the cost. After all, we are trying to make an article which will occupy a certain space, and the lower the volume cost of the compound, the cheaper the article can be made provided the physical properties are satisfactory.

The cost of a molded article is based on four things: (1) the cost of materials, which varies little with the number of articles required; (2) the press charge or cost for vulcanization, which can be reduced greatly if the number required permits elaborate tooling and multiple cavity molds; (3) the labor required for preparation of metal inserts, hand trimming, dry ice tumbling, buffing flash lines, etc.; and (4) the amortization of molds and tooling, which is sometimes a major item. Overhead is not made a separate item here as it is usually included as a percentage of labor.

From the above several things should be noted: (*a*) Since materials are only a small percentage of the cost of most rubber articles, the best possible compound for the purpose can usually be obtained at only a small increase over a cheap and unsatisfactory compound, and an article that ages well costs only a little more than one which deteriorates badly in a few months. (*b*) If the design is fixed, it pays to tool up properly to reduce the press charges, but this, of course, makes any changes in design quite expensive. (*c*) The rubber manufacturer should be consulted in connection with details of design which might affect the flash where the mold closes or cause blisters, airtraps or difficulty in opening the mold, as frequently a simple change will speed up operations. (*d*) As specific gravity determines the weight of the product and shipping charges are frequently an important item, the specific gravity of different compounds should be taken into consideration in relation to other physical properties and the lightest one selected which proves satisfactory. (*e*) Once a satisfactory product has been obtained, it should be understood by the manufacturer that any changes he wishes to make must be checked with the customer and tested if necessary before adoption.

A rubber manufacturer will not normally disclose to the customer the exact formula used in his product, as this is information that might be of considerable help to a competitor. On the other hand, principles of compounding are now well established and are freely discussed by rubber men and their material suppliers. Moreover it is usually possible to develop several quite different compounds which will have almost identical physical properties.

However, it is still possible to give the formula for a compound to six different manufacturers and secure products from the same mold which have six different sets of physical properties, due to differences in compounding practice, stock preparation, curing time, etc. Therefore the customer is wise to rely as much as possible on relevant physical tests from test sheets or blocks which the manufacturer will furnish

RAYMOND B. STRINGFIELD, president, Fullerton Mfg. Co., Fullerton, Calif., has been connected with the rubber industry since joining Goodyear in 1920, where he was manager of service laboratories in Akron and chief chemist at Los Angeles. Since 1930 he has been a consultant specializing in rubber and plastic problems and technical evidence.

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* Presented at the Second Pacific Area National Meeting in Los Angeles, September, 1956.

and guarantee to be made from the same compound and given a cure comparable to the article, plus such tests as are feasible on the finished product.

Actual Cases Prove Points

A few examples of what can and does happen will illustrate these points.

Some months ago a local manufacturer of ladies' underwear suddenly began to receive complaints that dresses used over his shoulder pads turned a bright yellow and did not become white with washing or dry cleaning. Investigation showed that the supplier of the sponge-rubber pads had changed rubber antioxidants with no thought of the effect of the change on possible discoloration. The manufacturer had to replace damaged dresses and the rubber supplier learned an expensive lesson.

A user of calendered rubber sheeting who was purchasing by the pound found that the specific gravity of the stock had been gradually increased by his supplier from 1.14 to 1.42 giving correspondingly fewer pieces per pound. A specification was immediately introduced.

A manufacturer of a product using a large molded rubber gasket found that his incoming gaskets, stored in a pile in diffused light indoors, would crack in a few hours on a smoggy day. Working with the gasket manufacturer, a formula was developed which resisted the ozone in the smog and eliminated the cracking at a very slight increase in cost.

A manufacturer of floor mats found that some of his product deteriorated to a sticky mass in a few months. Investigation showed that one lot of rubber used had been slightly contaminated with copper and manganese, which promoted oxidation.

A manufacturer of oil tools found tears in some of his rubber parts in service which were traceable to laminations formed during the molding. Changing the molds to use transfer molding completely eliminated the trouble and shortened the time of cure.

A cannery found that rubber parts on their can-sealing machines lasted only a few days and much time was lost in changing. By making the parts of oil-resistant rubber with maximum abrasion resistance, life was extended to months at only a small increase in cost.

These are just examples of the hundreds of problems which arise in the daily use of commercial rubber products. The rubber manufacturer usually does his best to find out as much as possible regarding the service to which the product will be subjected, but too frequently there are few data available as to the properties really needed.

ASTM Standards

Here is where ASTM comes in, and the materials engineer or consultant, as well as the rubber manufacturer, will usually find that study will enable these requirements to be pinned down in terms of tensile strength, modulus, elongation, permanent set, low-temperature flexibility, etc. ASTM Committees D-11 on Rubber and Rubber-Like Materials and D-9 on Electrical Insulating Materials have given us a whole series of methods for determining these properties, and a general specification D 735[1] for Rubber and Synthetic Rubber Compounds for Automotive and Aeronautical Applications which covers a whole set of compounds of natural and synthetic rubber with a wide range of properties that meet most industrial requirements. SAE 10 R is an identical specification developed jointly with the Society of Automotive Engineers.

For instance, grade R 620, one of the grades in Specifications D 735, designates a natural rubber compound of 60 shore durometer hardness, 2000 psi tensile strength, 400 per cent ultimate elongation, and one which does not decrease more than 25 per cent in tensile strength and elongation after aging for 70 hr at 158 F. If compression set is of importance, adding the suffix B will add the requirement that the compression set after 22 hr at 158 F be not over 25 per cent. Similar suffixes can be added to specify weather resistance, load deflection, tear resistance, low-temperature flexibility, adhesion to metal, nonstaining characteristics, and even special tests agreed upon between the manufacturer and the user.

Where resistance to oil swelling is required, synthetic rubber compounds are commonly used, and here grade SC 620 designates a neoprene-base compound, 60 shore durometer hardness, 2000 psi tensile strength, 350 per cent elongation, and 40 to 110 per cent swell in ASTM No. 3 oil after 70 hr at 212 F, while changing to grade SB 620 designates an acrylonitrile base compound such as Hycar or Paracril with the same tensile strength and elongation properties but with the swell in ASTM No. 3 oil after 70 hr at 212 F reduced to 0 to 50 per cent.

ASTM methods are available to show comparative resistance to ozone, abrasion, tear, crack, or cut growth, to give electrical properties, and for many other special purposes. In cooperation with the rubber manufacturer, it is sometimes necessary to specify certain points in processing such as the preparation of metal inserts, the use of transfer molds to avoid lamination, the finish of the mold surface, and the lubricant used to prevent sticking to the mold. All this, however, merely means that the materials engineer and the rubber manufacturer must try to learn each other's problems and requirements and that usually a specification based on the ASTM classifications and tests can be drawn up which will assure the customer a satisfactory product, tell the rubber manufacturer what is required, and protect both customer and manufacturer from irresponsible competition.

DISCUSSION

MR. K. R. JACKMAN.[2]—We have some research now going on in our laboratory in which we have a comparison between a rubber O-ring and a Teflon O-ring. It would be a great help to the engineers to have some correlation in the relative characteristics of those materials. Does it involve both the rubber and the plastics committees in attempting to find comparative specifications?

MR. STRINGFIELD (*author*).—Probably so. ASTM Committee D-11 establishes the rubber specifications. ASTM Committee D-20 prepares the plastics specifications. The exact testing methods are sometimes not applicable across the board. It is one of those things. Those who have served on these committees know the things that are encountered and frequently a special test can be developed if indicated.

MR. ROBERT STRICH.[3]—One of our difficulties in specifying rubber parts is determining the type of test to be performed. Are we going to test the test slabs as many of the ASTM specifications indicate, or are we going to test the actual parts produced? The difficulty is that when we obtain rubber parts from a vendor we have little assurance of knowing that the test slabs and the actual parts come from the same stock and are produced under identical conditions. We do not know whether the parts are going to behave in the same way as the test slabs behave.

[1] Tentative Specification for Elastomer Compounds for Automotive Applications (D 735–55 T), 1955 Book of ASTM Standards, Part 6, p. 1203.

[2] Senior, Test Lab., Group Engr., Engineering Test Labs., Convair, Pomona, Calif.

[3] Product Engineering Supervisor, Cannon Electric Co., Los Angeles, Calif.

A typical problem is that of determining the common and important characteristic of durometer hardness. Most of our rubber parts have insufficient cross-section to give us an accurate reading. When we use test slabs supplied with the lot, we cannot be sure that they were produced in the same manner as the rubber parts.

Can the author give us some indication of how other users of rubber parts are facing the problem?

MR. STRINGFIELD.—One of the difficulties in the rubber picture is the fact that as yet a great many rubber companies do not have adequate technically trained personnel. For instance, we have 126 rubber companies in Southern California and in that group at least 50 per cent of them have no technically trained personnel at all.

However, another item is in the problem that you mentioned—that is, to be sure that the production cure is correlated with the cure of the test slab. Frequently, on your gaskets and O-rings, there is no part that is adaptable to ordinary tests. You can rig up some specification tests that will correlate the figures you want for your own purposes. But the only way that you can get a test that will be comparable between several different stocks on a laboratory basis is to use laboratory test sheets and blocks; and there you have to be sure that your laboratory cure and your production cure are correlated. Now, the thicker an article, the longer the time that has to be allowed, and in the cure of rubber you range from an under cure to an over cure, and that time may be short or long depending on the type of compound. One compound may be satisfactorily cured, let us say, in 5 min and will stand 1 hr before it becomes over cured. On the other hand, a compound of somewhat similar properties could be cured in 5 min and be over cured in 10 min. That is where you need to work with your rubber manufacturer to be sure that the cure has been adjusted so that it will not be too critical and that the cure is carefully controlled in production so that it actually does tie in with the cure in the laboratory. You cannot determine hardness with our present methods, adequately, with anything less than $\frac{1}{4}$-in. thick specimens.

Asphalt Research at the National Bureau of Standards

By H. R. SNOKE

ASPHALT research at the National Bureau of Standards dates back to the early days of the Bureau, the main objective of the early work having been the development of test methods and specifications for roofing asphalts and asphaltic products. The first drafts of the Federal Specifications for roofing asphalt, asphalt prepared roofing and shingles, asphalt varnish, asphalt primer, and others, complete with test methods, were prepared in the Bituminous Laboratory of the Bureau's Chemistry Division.

In 1926, the Asphalt Roofing Inst., currently the Asphalt Roofing Industry Bureau, an association of manufacturers of asphalt roofing products, established a fellowship at the Bureau, under the Research Associate Plan, for research on asphalt and asphalt roofing. This fellowship operated continuously from 1926 to 1947 with one research associate, and since 1947 usually with three. In addition, two NBS employees currently spend practically full time on this research. It has been carried on in the Floor, Roof, and Wall Coverings Section, Building Technology Division, since 1947.

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

In view of the importance of exposure to weather of asphalt roofing products, the effect of weather on asphalt has been of primary concern in the work of the fellowship from its inception. In the early 1920's, so-called accelerated weathering tests were coming into prominence, and it was only natural that an effort should be made to develop accelerated tests to simulate longtime outdoor exposure. This was pioneering work which involved the investigation of various light sources; the effects of temperature; the amount of water that should be used and how it should be applied; methods for preparing test specimens and for evaluating the results of exposure, etc. Each item was an investigation in itself, but there finally evolved a system of accelerated tests about which it was possible to conclude that similar results are obtained when asphalts are exposed to accelerated weathering and to outdoor weathering and that asphalts show a characteristic behavior when exposed to accelerated weathering (1).[1]

Accelerated weathering tests were used in various phases of the asphalt research, but the results of such tests were always verified, insofar as possible, by actual outdoor exposures. In one phase of the study it was shown for the first time that products soluble in water were formed when asphalt was weathered, and the function of light and water in the weathering process was elucidated (2).

Accelerated weathering was used also in an attempt to evaluate the performance of asphalt shingles from a number of manufacturers. From this work it was concluded that all of the types of failure encountered in long outdoor exposures of these roofings can be produced in a relatively short time by accelerated weathering (3). Outdoor exposure of duplicate specimens of these shingles verified this conclusion 15 years later.

Asphalt Additives

Early asphalt roofings employed only straight asphalts as coatings for the saturated felts. However, some manu-

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facturers soon began using fine mineral additives with the asphalt to deter the flow of coatings at service temperatures. In many cases an apparent improvement in the weather resistance of roofings made with such coatings was noted. To determine the effectiveness of additives that were in common use, and of a few that were used but little if at all, specimens were prepared using 15, 25, and 35 per cent of the additives in a common asphalt blend. These specimens were exposed for three years outdoors in Buffalo, N. Y., Manville, N. J., Chicago, Ill., Los Angeles, Calif., New Orleans, La., and Washington, D. C. One set was also exposed to accelerated weathering. This work demonstrated that mineral additives, in general, increased the durability of asphalt coatings, the higher percentages of additive (maximum 35 per cent) usually producing the greater durability. Again the results of accelerated and outdoor exposures were similar (4).

This work, while strengthening the position of roofing manufacturers who were using mineral additives, left many basic questions unanswered. Among the foremost of these were the behavior of asphalts from different sources and the effect of introducing additives in quantities greater than 35 per cent. Consequently, when the fellowship was enlarged in 1947, an additive program much larger in scope than the previous one was started. This program included 14 different mineral additives and three asphalts from different sources.

Prior to starting the program, the previous methods of handling and testing asphalt coatings were investigated and some of them revised to control more variables. Two new procedures were developed for the preparation of exposure specimens. In one, extremely thin uniform films of asphalt were prepared by pouring the molten asphalt on rapidly spinning disks, the thickness of the film being controlled by the speed of the disk and the viscosity of the asphalt (5). The other used a hydraulic press to produce uniform films of asphalt on conventional aluminum plates (6), without the accompanying high rejection rate and other limitations of the doctor-bar method (1).

Past experience had indicated the reliability of accelerated tests of asphalt coatings, but to insure greater reliability the machines were moved to an air-conditioned laboratory and modified for better control of the important variables of light, water, and temperature (7).

Several different sets of exposure conditions were evaluated to determine the most effective system (8). It was found that, within the precision of tests of this type, a number of cycles differentiated among the asphalts in the same order. As the severity of exposure was increased, the durability of the asphalts was decreased and the differentiation among asphalts became less distinct. It was found also that the use of chilled water (40 F) eliminated the necessity of transferring the specimens daily to a refrigerator (9).

The results of the most recent additive program have been published recently (10). In this study it was found that, within the limits investigated, durability generally increased with both coating thickness and mineral additive concentration. While the durability of the more durable asphalts was increased by almost all of the additives, that of the least durable asphalt was increased appreciably only by the additives with plate-like particles. The foregoing is, of course, an oversimplified statement of the results obtained. The outstanding new fact learned from this program was that of the paramount importance of the asphalt in determining the durability of a coating.

Photo-oxidation Degradation

The results of the additive work fully justified the decision to undertake a large-scale study of the photo-oxidation degradation of asphalt. Several approaches to this problem are under way. In one, a chromatographic method for separating asphalt into distinctive groups of components (11) has been developed. This method is more rapid and, at the same time, more precise than the modification of Marcusson's method published previously (12). It has been used to determine the differences among asphalts from various sources and the changes that occur during outdoor and accelerated exposure. Twenty-one asphalts, varying in durability over a sixfold range, have been secured. Changes in components and chemical changes in two of these asphalts, representing the less durable and more durable asphalts, have been followed during 3500 hr of accelerated exposure. Many differences were observed in both the rates of changes in components and in the way the minor chemical elements migrated among the components and into the degradation products.

Because of the extremely complex nature of asphalts and because differences in the degradations of asphalts appeared to be a question more of degree than of type, it was decided to direct a phase of the research on the products of degradation, with particular attention first to the water-soluble degradation products. A relatively large quantity of water-soluble degradation products has been collected from one of the more rapidly degrading asphalts. These products have been analyzed completely and are characterized in a paper soon to be published (13). Exploratory chromatographic analysis of a portion of this material, after passage through a cation-exchange resin to remove contaminating metal cations and careful vacuum drying, yielded no less than 10 distinct groups. Quantities of these groups sufficient for identification are being collected.

An apparatus constructed recently will make it possible to follow the rate of oxidation of asphalt as a function of the wavelength of light used, thickness of the asphalt film, temperature, and oxygen concentration. Provision is made also for the collection of all degradation products.

Admittedly we have embarked on a long road, the end of which is not yet in sight. However, it is hoped that if we can elucidate the mechanism of the degradation process, steps can be taken to modify it so that less durable asphalts may be upgraded and the more durable ones made even better. Also, it may prove the stepping stone to that ultimate aim of the asphalt consumer—the ability to specify quality rather than physical characteristics when he purchases asphalt.

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Water-Soluble Degradation Products of Asphalt

BY ALAN SCHRIESHEIM AND SIDNEY H. GREENFELD

This progress report covers the preliminary findings of an investigation of degradation products formed in the interval between 550 and 850-hr exposure in an accelerated weathering machine

SUNLIGHT or strong artificial light is essential for the aging of asphalt at moderate temperatures in the presence of air (**1,2,3**).[1] The changes that occur on such exposure are complex and little understood (**1**).

Strieter and Snoke (**2**) were the first to report that water-soluble materials are formed when asphalt is exposed to oxygen and light. They found that both light and oxygen were necessary to produce these products. These water-soluble materials were reported to be acidic, to reduce Fehling's solution, and to contain ketonic acids. Thurston and Knowles (**3**) conducted a similar study on asphalt components and found that each component formed water-soluble degradation products. Fair, Beck, and McKee (**4**) confirmed the findings of Strieter and Snoke and reported that various asphalts degraded at different rates. Kleinschmidt found variations in the rate of formation of these materials with film thickness.[2]

These degradation products are more amenable to analysis than the asphalt, which is a mixture of materials of relatively high molecular weight. This paper covers the preliminary findings of an investigation of the nature of the water-soluble degradation products formed in the interval between 550 and 850 hr of exposure in an accelerated weathering machine.

Experimental

Specimen Preparation and Exposure

A blown, shingle-grade coating asphalt with a softening point of 89 C was cast as films 25 ± 1 mil thick on 65 mil thick aluminum panels by the hydraulic press technique (**5**).

The specimens of asphalt were exposed in an accelerated weathering machine for 22-hr periods. At the end of each period they were taken from the machine and soaked in a distilled water bath for 45 min and then soaked for 15 min in a second distilled water bath. The panels were at ambient conditions (25 ± 1 C) without light exposure for the twenty-fourth hour and for 49 hr over each weekend.

The isolation of the water-soluble materials collected in the interval between 550 and 850 hr of exposure was accomplished by evaporating the aqueous solutions to dryness in a partial vacuum at 40 C, after having been passed through a cation-exchange resin bed.

Chemical Analyses

Oxygen was determined directly by the Unterzaucher method, as modified by Aluise (**6**) and by Dundy and Stehr (**7**). Carbon and hydrogen were deter-

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[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] Private communication from L. R. Kleinschmidt, National Bureau of Standards.

mined by the conventional micro-combustion method as described in Niederl and Niederl (**8**). Nitrogen was determined by the procedure developed by Alford (**9**).

After oxidizing the material in a Parr Bomb, sulfur was determined as sulfate by titration with a solution of barium chloride using potassium rhodizonate as an indicator (**10**).

Molecular Weights

Molecular weights were determined by an ebullioscopic method using methyl ethyl ketone as a solvent. The apparatus used and the techniques involved have been described by Matteson (**11**).

Ultraviolet and Infrared Spectra

Absorption spectra of the water-soluble materials were measured on a Beckmann DU quartz spectrophotometer. The solvents were distilled water and 0.1 *N* aqueous sodium hydroxide. Molar extinction coefficients were calculated from the recorded optical densities, solution concentrations, and molecular weights.

The infrared transmission spectra were recorded on a Model No. 21 Perkin-Elmer double beam instrument. The powdered solid degradation products were incorporated in KBr pellets for these measurements.

Cation-Exchange Resins

Salts of the degradation products were converted to the free acids by passage through a cation-exchange resin bed 18.5 mm deep and 15 mm in diameter, the particle size of the resin being between 44 and 125 μ. The type (cross-linked sulfonated hydrocarbon) of cation-exchange resin and particle size were selected in order to minimize the van der Waals type of organic acid adsorption (**12,13,14,15**). Preliminary work with a sulfonated, phenolic type cation-exchange resin indicated that it removed some of the organic acids as well as the metallic cations.

The sulfonated hydrocarbon-type cation-exchange resin had been previously activated in the usual manner by several successive cycles of treatments with 5 per cent sodium hydroxide, 10 per cent hydrochloric acid, and distilled water. In order to determine whether the resin could quantitatively exchange its hydrogen for a metallic cation, 1 liter of a solution containing 2.23 Meq of potassium acid phthalate was percolated, under suction, through the column at a rate of 1.3 ml per sec. The bed was then washed with 400 ml of water and the total effluent titrated. The recovery of dibasic acid was quantitative.

To determine whether impurities were introduced by solution of the resin, 1500 ml of distilled water were percolated through the bed at a rate of 1.3 ml per sec. This solution was then evaporated to dryness and yielded a residue that was unweighable.

One liter of a solution containing approximately 300 mg of the water-soluble degradation products was then percolated through the bed under suction. Taking the cation removal into account (see Table II), vacuum-evaporation of the effluent again yielded a quantitative recovery.

After passage of about 26 liters of a solution containing water-soluble material through the cation-exchange resin and after washing the resin with distilled water, the resin was washed with 1500 ml of dilute sodium hydroxide. This sodium hydroxide wash had an orange color which faded when the solution was neutralized with dilute hydrochloric acid. This neutral solution was then vacuum-evaporated to a volume of 50 ml.

Results and Discussion

Properties of Water-Soluble Materials

The asphalt chosen for this work was one that was known to yield a relatively large quantity of degradation products in a short time. It was anticipated that the methods of identification developed for these degradation products could be applied to a study of the water-soluble degradation products obtained from other asphalts.

In Table I are shown the chemical analyses of the entire coating of asphalt removed from two different specimens, one before exposure and the other after about 37 cycles of exposure as described in the experimental section.

TABLE I.—CHEMICAL ANALYSES OF EXPOSED AND UNEXPOSED ASPHALT.

Component	Unexposed Asphalt, per cent	Exposed Asphalt, per cent
Carbon	84.6	75.8
Hydrogen	10.5	9.2
Oxygen	1.7	3.2
Nitrogen	1.7	1.2
Sulfur	2.2	1.9
Weight loss	...	8.8
Total	100.7	100.1

It is noted that the oxygen content increased from 1.7 to 3.2 per cent indicating that all of the oxidized material had not become water soluble.

The acidic degradation products reacted with the aluminum specimen holders to form the corresponding salts. In order to prepare the free acids, the water-soluble materials were passed through the cation resin. Titration curves for this acidic material before and after passage through the resin are given in Fig. 1. Before passage through the resin, the solution contained about 0.5 g per liter and 100 ml of solution required about 3.1 ml of 0.0627 *N* base for neutralization. After passage through the resin, the material required approximately 50 per cent more base. The titration curves were not sharp; the slope at the lower pH ranges indicated the presence of at least one weak acid. Preliminary work with anion-exchange resins and chromatographic methods of separation indicated that more than one acid was present in the degradation materials.

In Table II are recorded the chemical analyses of the water-soluble materials before and after passage through the cation-exchange resin.

TABLE II.—CHEMICAL ANALYSES OF WATER-SOLUBLE MATERIALS BEFORE AND AFTER PASSAGE THROUGH THE CATION-EXCHANGE RESIN.

Component	Before Resin, per cent	After Resin, per cent
Carbon	45.4	49.8
Hydrogen	4.8	5.7
Oxygen	34.6	35.6
Nitrogen	1.9	1.3
Sulfur	4.1	5.3
Ash	9.0	2.2
Total	99.8	99.9

Spectrographic analyses of the ash content of the degradation products before passage through the resin revealed moderate amounts of aluminum, calcium, magnesium, silicon, and zinc. All but the silicon were removed or greatly reduced in amount upon passage through the cation-exchange bed. Silica, as silicic acid, was not removed by the cation-exchange resin; its presence was probably due to the contamination introduced by the ceramic crocks used in the collection of the acids.

Because of the decrease in the inorganic constituents, the percentages of the elements that remained were expected to increase. This apparent increase was observed for the elements other than nitrogen. Nitrogen present as a basic compound, such as an amine, can be absorbed by a cation resin. Qualitative tests reported in a later section indicated that some nitrogen-containing compounds were removed by the ion exchange resin.

The salt-free degradation products were brownish-black hygroscopic solids with a melting range of 140 to 180 C. They were soluble in water, ethanol, and ketone solvents such as methyl ethyl ketone and almost insoluble in the lower boiling ethers and aliphatic and aromatic hydrocarbons. Ebullio-

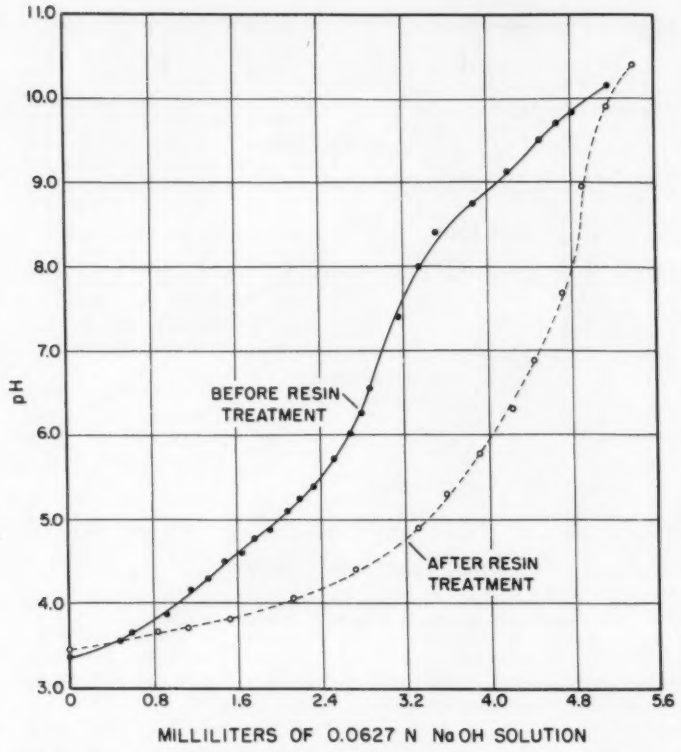

Fig. 1.—Titration of Water-Soluble Degradation Products Before and After Passage Through the Cation-Exchange Resin.

scopic values of their molecular weights in methyl ethyl ketone fell in the range of 400 to 420. Equivalent weights of 167 to 175 indicated an average of about 2.4 carboxyl groups per molecule.

The infrared curves of the water-soluble materials before and after passage through the cation-exchange bed are presented in Fig. 2. Although the water-soluble materials when heated to 100 C became largely insoluble in water, the infrared curves before and after heating were coincident.

The results of some of the qualitative tests reported in a later section are supported by the infrared transmittance curves. The degradation products before passage through the cation-exchange resin exhibited typical N—H stretching vibrations at 2.9 and 3.1 μ, as well as N—H deformation vibrations at 6.1 μ. These bands were reduced in intensity after the material had been passed through the resin. It was expected that the cation-exchange resin would remove primary and secondary amines, and the above results can be interpreted on this basis.

The region between 3 and 3.5 μ shows broad carboxyl O—H stretching vibrations both before and after passage through the cation-exchange resin, and the 5.8 μ band can be correlated with the carboxyl carbonyl stretching frequency. The strong influence of the carboxyl group also is evident in the general absorption in the 8 to 10 μ region, which is probably due to the C—O stretching vibrations.

The bands at 3.4 and 7.2 μ are probably due to aliphatic C—H stretching and $-CH_3$ deformation vibrations, respectively. Their weak intensity indicates the low concentration of these substituents and is consistent with a highly oxidized type of structure as the major constituent of the degradation products.

The ultraviolet absorption spectra of the free acids in water and in base are shown in Fig. 3. The spectra of the free acids do not show selective absorption as do the benzene-carboxylic series (16) contained in the envelope in Fig. 3. It should be noted that the spectra of the latter series were determined in methanol. However, the difference in solvents would not be expected to mask similarities in structure. The extinction coefficients for acids of the latter series fall within this definite envelope with a marked hump in the range of 280 to 310 mμ. As with the acids produced from the oxidation of coal, the mixed acids from asphalt "show absorption outside this band and especially at the longer wavelengths where the multi-ring condensed types are known to exhibit absorption" (16).

Because of the lack of definite absorption bands, specific interpretation

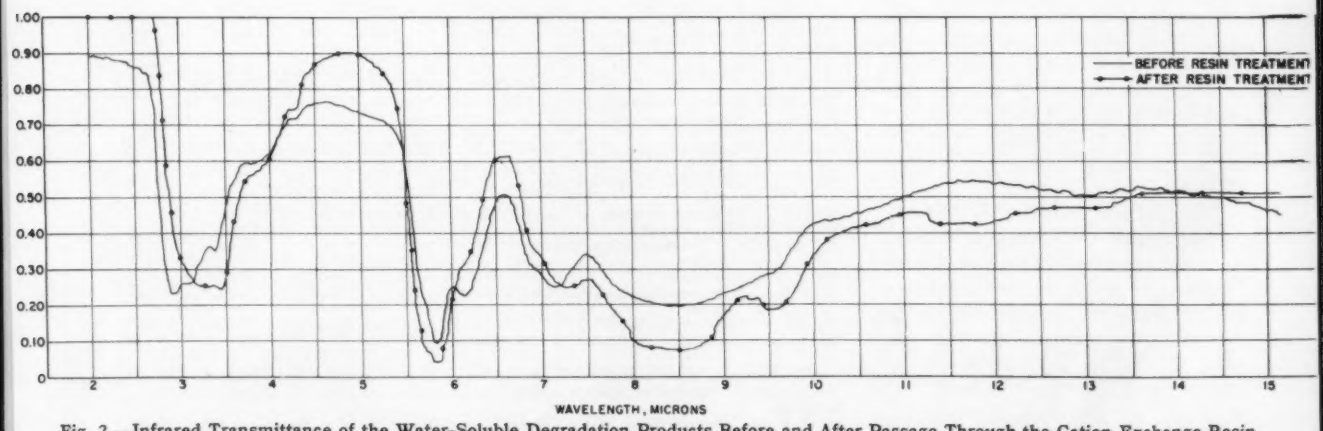

Fig. 2.—Infrared Transmittance of the Water-Soluble Degradation Products Before and After Passage Through the Cation-Exchange Resin.

is impossible. However, the increase in absorption upon the addition of base is characteristic of phenolic and enolic type compounds (17).

Nature of the Salt-Free Degradation Products

In Table III are recorded the results of a series of qualitative organic analytical tests that were applied to the water-soluble degradation products that had been passed through the cation-exchange resin.

Little or no oxygen was present as an aldehyde (tests 3, 4) or a keto group (tests 1, 2). Calculations based on a molecular weight of 400 and an average of 2.4 carboxyl groups per molecule accounted for 19 of the 36 per cent of oxygen present.

The qualitative tests coupled with the ultraviolet spectra of the previous section indicated the presence of phenols or enols (test 6). Enols were eliminated by the absence of a reaction with the usual ketone reagents (tests 1, 2). The positive cobaltinitrite test (test 9) and the absence of a positive Millon (test 7) or nitroso (test 8) test suggested that some of the phenols present were substituted in the para, but not in the ortho position.

The ease of oxidation of these materials (tests 18 and 19) might indicate the presence of polyhydroxy phenols, which could account for the remaining 17 per cent of the oxygen.

There was a positive test for a 1,2-dicarboxylic acid (test 5) and another positive test for an active methylene group (test 20).

Oxygen may be present in other forms such as esters and ethers. The exact manner in which the remaining oxygen was present cannot be determined until the materials have been fractionated into pure components.

The sulfur that was present was not in the form of a sulfonic acid, sulfinic acid, sulfone, or sulfonamide (test 15). The material gave a positive sodium azide test (test 16), indicating the presence of a thioketone or mercaptan.

The small amount of nitrogen that was present was not in the form of a pyrrole (test 17), amine (test 22), amino acid (test 21), or amide (test 23).

The positive furfural test (test 24), indicated the presence of a material that can condense to form a furfural nucleus. Under these test conditions a carbohydrate is usually indicated. However, the negative periodate test (test 13) and the prior history of the sample would make this conclusion very unlikely. At this time the only conclusion possible is that a substance is present that will condense in the presence of phosphoric acid to form a furfural nucleus.

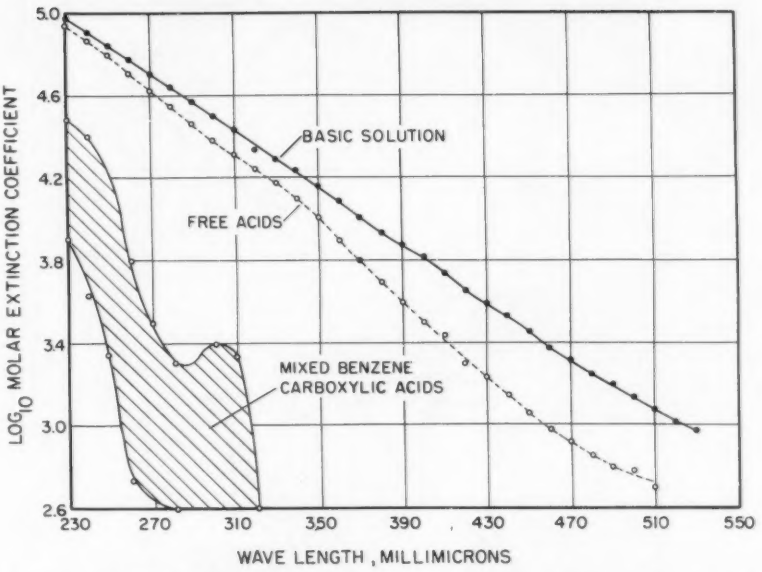

Fig. 3.—Extinction Coefficients of the Salt-Free, Water-Soluble Degradation Products in Water and in a 0.1 *N* Sodium Hydroxide Solution.

Nature of the Organic Material Contained in the Sodium Hydroxide Eluate of the Cation-Exchange Resin

The neutralized sodium hydroxide eluate of the cation-exchange resin was tested for basic compounds that might be present in the form of amines or amino acids.

Paper chromatography, using ninhydrin as a spray reagent, revealed a large blue spot about half way to the solvent front, indicating the presence of an aliphatic amine or amino acid. Due to the low concentration of this substance, no estimation was made of its concentration.

TABLE III.—QUALITATIVE ORGANIC ANALYSES OF WATER-SOLUBLE MATERIAL AFTER PASSAGE THROUGH THE CATION-EXCHANGE RESIN.

Test	Test or Reagent	Functional Group	Results	Reference[a]
No. 1	Phenylhydrazine	Carbonyl	Neg.	
No. 2	2,4-Dinitrophenylhydrazine	Carbonyl	Neg.	
No. 3	Fuchsin-aldehyde	Aldehyde	Neg.	156
No. 4	Methone	Aldehyde	Neg.	
No. 5	Resorcinol fusion	1,2-Dicarboxylic acid	Pos.	175
No. 6	Ferric chloride	Phenolic or enolic	Pos.	
No. 7	Millon	Phenolic	Neg.	134
No. 8	Nitrous acid	Phenolic	Neg.	132
No. 9	Cobaltinitrite	Phenolic	Pos.	[b]
No. 10	Ceric nitrate	Alcohol	Inc.[c]	132
No. 11	Alkali-xanthate	Alcohol	Inc.[c]	129
No. 12	Nitrochromic acid	Alcohol	Neg.	
No. 13	Periodate	Dihydroxy compounds	Neg.	131
		Polysaccharides	Neg.	131
No. 14	Sodium hydroxide	Sulfur compounds	Pos.	181
No. 15	Benzidine acetate	Sulfonic acid	Neg.	182
		Sulfonamide	Neg.	
No. 16	Sodium azide	Mercaptans and thioketones	Pos.	164
No. 17	*p*-Dimethylaminobenzaldehyde	Pyrroles	Neg.	199
No. 18	Fehling's solution	Oxidizable compounds	Pos.	
No. 19	Tollen's reagent	Oxidizable compounds	Pos.	
No. 20	1,2-Naphthoquinone 4-sulfonate	Reactive methylene or amine grouping	Pos.	222
No. 21	Ninhydrin	Amino acids	Neg.	
No. 22	*p*-Dimethylaminobenzaldehyde	Amines	Neg.	203
No. 23	Fluorescein chloride	Amides	Neg.	197
No. 24	Furfural	Carbohydrate	Pos.	288

[a] The numbers refer to pages in F. Feigl, "Spot Tests," Elsevier Publishing Co., New York, N. Y. (1954). The other tests are standard and may be found in any qualitative organic textbook.

[b] F. Feigl, "Organic Spot Test Analyses," *Analytical Chemistry*, Vol. 17, p. 1315 (1955).

[c] Inconclusive.

Determination of the actual manner in which the elements are present in the water-soluble degradation products of asphalt is dependent upon a final separation of the components. At present this laboratory is engaged in developing such methods of separation.

Acknowledgment:

The authors wish to acknowledge the aid of James Stewart, James Cassel, and Richard Carlin, of the staff of the National Bureau of Standards, and John Falzone and Shigeru Ishihara, Research Associates for the Asphalt Roofing Industry Bureau, in collecting the data for this paper. The authors would also like to express their gratitude to L. R. Kleinschmidt for his helpful advice and comments.

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Production and Fabrication of New AISI Types 201 and 202*

By G. W. HINKLE

Shortage and possible restrictions of nickel supply result in new low-nickel stainless steels

THE CHEMICAL and physical characteristics of AISI 201 and 202 alloys have been ably discussed in the previous papers. The purpose of this paper is to present the production and fabrication characteristics of these alloys.

During the war there were limited tonnages of AISI type 201 steel melted and produced for specific application, primarily transportation equipment. A limited knowledge of production problems was gained at that time. However, the production was confined primarily to narrow strip products of high tensile properties. The fabrication problems were fairly simple, being restricted to cold forming and rolling to shapes and welding. Surface finish was not a serious problem.

The present proposed program for these alloys is to replace AISI types 301 and 302 in a broad general application where deep drawing, forming, rolling, stretch forming, perforating, welding, forging, and polishing to a high finish will be required. It will now be necessary to produce these steels in the wide range of sizes, gages, tensile strengths, and surface finishes required for standard commercial stainless steel consumption. With the present emphasis on production and manufacturing costs in industry, these steels will have to be produced at costs at least commensurate with types 301 and 302, and since their selling prices are lower, their fabrication characteristics must be at least equal to the steels they will replace.

The production of types 201 and 202 has been confined during the past several months to experimental production heats necessary to determine limits on chemical composition for best production and general fabrication qualities. Samples have been submitted to customers in quantities suitable for developing customer reaction to fabrication, tooling, welding, and polishing. There could readily be a general acceptance of these steels for cooking utensils, soda fountain, restaurant equipment, household appliances, automotive, and architectural applications if nickel availability continues to be as critical as at present.

Melting

The steels are melted to the chemical composition ranges shown in Table I.

The melting procedure varies from the normal practice for types 301 and 302 only as required by the high manganese and nitrogen content of the steel. Republic Steel employs the normal scrap charge, using oxygen blow for carbon oxidation, followed by lime and silicon reduction for chromium recovery. Nitrogen is controlled by additions of high-nitrogen chrome pellets. Man-

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* Presented at the 59th Annual Meeting of the Society in Atlantic City, N. J., June, 1956.

TABLE I.—CHEMICAL RANGES FOR AISI TYPES 201 AND 202 STEELS.

	Type 201	Type 202
Carbon, max per cent	0.15	0.15
Manganese, per cent	5.5 to 7.5	7.5 to 10.0
Phosphorus, max per cent	0.06	0.06
Sulfur, max per cent	0.030	0.030
Silicon, max per cent	1.00	1.00
Chromium, per cent	16.0 to 18.0	17.0 to 19.0
Nickel, per cent	3.5 to 5.5	4.0 to 6.0
Nitrogen, max per cent	0.25	0.25

ganese is added as electrolytic manganese by two additions at the end of the heat to effect best recovery. Reladling is employed. Magnesite nozzles are used for best pouring practice and tapping temperature is controlled closely at approximately 2740 F to 2750 F. No material difference has been noted in ingot production relative to pouring and ingot surface.

Blooming Mill Operation

Due to the stiffness of these alloys at rolling temperature, imparted by the high manganese and nitrogen content, considerable difference has been noted in the heating and rolling practice for conversion of ingots to slabs and billets.

Heating in soaking pits requires more care and control of rate of heating, soaking, and rolling temperature. The best practice has been to charge warm, keep close control of heating rate to 50 F per hr, soak out well at 1800 F, and roll at 2250 F to 2270 F. High side temperatures are used on large ingots. There is now an over-all increase in soaking pit time of 20 per cent compared to types 301 and 302.

No great difficulty has been encountered in rolling small slab ingots up to 16 by 32 in. (9000 lb) of either types 201 or 202. However, the power required is greater and the reductions somewhat lighter. The production is slower, approximately 10 per cent lower on type 201 and 20 per cent on type 202, in tons per hour on single conversion practice.

Type 202, being stiffer at rolling temperatures than type 201, presents a greater problem to blooming mill operations. Since this alloy is intended to replace type 302, it will be required to produce wide slabs for continuous strip sheet mill operations, 48 in. and 60 in. wide. This requires larger and heavier ingots. Heating and soaking temperature is more critical. Power limits on established blooming mill equipment are seriously burdened. For single conversion of these ingots, power limits in some cases will have to be considerably increased on existing equipment, or resort to double conversion. In either case, this will mean higher conversion costs and possible lower yields. However, as tonnage increases, it is hoped that these problems can be reduced by modified melting and heating procedures.

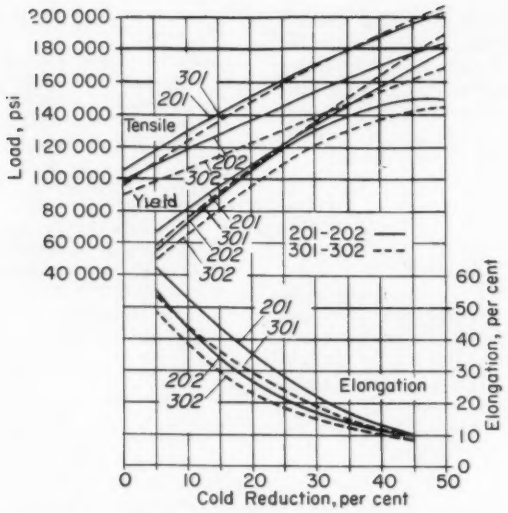


Fig. 1.—Chart Showing Cold Rolling Practice for High Tensile Properties. (By Courtesy of AISI.)

Conversion of Slab to Strip Product

Hot rolling of slab to hot strip has presented no problems. In cold rolling strip to gage for annealed No. 1 or No. 2 finish, types 201 and 202 appear to be harder and require 15 to 20 per cent more passes for equal gage reduction. Also hardness builds up more rapidly. It has been found necessary to enter the Z-mill at a lighter gage or, if the gage is equal to use more and lighter passes to finish gage.

Little difficulty is encountered in developing high tensile requirements on type 201, requiring approximately 10 per cent less reduction to meet half-hard requirements.

Changes are necessary in annealing and pickling procedure. Annealing temperature must be lowered since these steels scale or oxidize more readily at temperatures in excess of 1600 F than do types 301 and 302. Acid pickling baths must operate at lower temperatures and concentrations. This is especially important when producing strip requiring polishing on finished parts such as cooking utensils or automotive parts.

Forging

Very little if any of types 201 or 202 has been shipped to commercial forge shops for regular production. However, it is felt that no difficulty will be encountered if minor changes are effected such as temperature and slightly more power required. Die life should not be materially affected; however scaling will be increased. Heating atmospheres may require closer control for die life and surface finish.

Machining

No data have been completely developed at this time to indicate definite characteristics.

Annealing

Full annealing of types 201 and 202 can be accomplished similar to types 301

TABLE II.—EFFECT OF LOWER ANNEALING TEMPERATURE.

Temperature, deg Fahr	AISI Type 202				AISI Type 201			
	Yield Strength, 2 per cent Elongation, psi	Tensile Strength, psi	Elongation in 2 in., per cent	Rockwell Hardness, 30T Scale	Yield Strength, 2 per cent Elongation, psi	Tensile Strength, psi	Elongation in 2 in., per cent	Rockwell Hardness, 30T Scale
1800	48 500	105 300	57.0	68.5	52 760	110 000	58.0	71.0
1800	49 650	103 200	56.0	68.5	52 420	113 000	59.0	72.0
1850	44 180	102 500	59.0	67.5	51 000	107 600	59.0	70.5
1850	44 780	101 600	59.0	67.0	50 940	106 700	59.0	70.5
1950	42 630	99 450	62.0	67.0	45 120	103 700	62.0	69.0
1950	42 190	99 610	65.0	66.5	47 190	102 400	62.5	68.0

and 302 at 1950 F with a quench or air cool as indicated by the section being processed. However, types 201 and 202 scale or oxidize more readily and, when finish must be maintained as on intermediate anneals on deep-drawn flat-rolled parts which are ultimately to be polished, the annealing temperatures should be lowered 100 F to 150 F for best results. This lower temperature will not develop maximum ductility for subsequent draw operation (Table II), however, no difficulty in this respect has been encountered to date.

Pickling

Standard acid pickling solutions should be lowered 10 F to 20 F and concentrations of HNO_3-HF acid solutions lowered approximately 10 per cent. However, temperature, concentration and time required will be governed by the type of scale developed by each individual specific operation, as these conditions will vary from plant to plant. Caustic pickling, either hydride or "Virgo," has proven satisfactory.

Brake and Roll Forming

One of the largest users of types 201 and 202 employing both brake and roll forming advises that these alloys can be shaped with identical tooling and operations as that used for types 301 and 302, and with equal or better results. Springback has been the same; however, we know that rolling light gage strip products at relatively fast speeds, springback will vary, especially on automotive parts that have been annealed at lower temperature to protect surface requirements. This can be corrected by tooling changes and will present no problems when designs change. This primarily means changes in radii.

Deep Drawing

This area of fabrication is of great concern since considerable tonnages of flat-rolled products are consumed annually for cooking utensils, automotive parts, and household appliances. Production runs for pots and pans, automotive hub caps and disks, electric range parts, washing machine tubs, and other household appliances have been very gratifying on both types 201 and 202. Pots and pans can be produced from type 202 on the same dies as used for type 302 and with little change in hold down pressure. In some cases, blank size must be increased slightly. The same has been true on automotive parts relative to types 201 and 301. Single draw washing machine tubs have reported the same situation.

The stainless steel sinks familiar to all have been produced from type 202 on the same dies as used for type 302 with complete satisfaction in a single draw operation. Blank size and hold down was increased slightly.

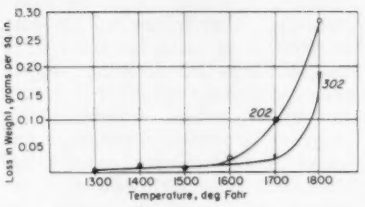


Fig. 2.—Chart Indicating Oxidation Characteristics of Types 202 and 302. (By Courtesy of AISI.)

Figure 3 indicates the gage and hardness on the complete cross section of sink section on types 202 and 302.

Polishing

The same procedure and technique used in grinding and polishing type 302 is entirely satisfactory for types 201 and 202. The same wheels, abrasive compounds, lubricants, and speeds are used for type 201 and 202 as on type 302 to develop the various finishes. Manufacturers of cooking utensils, automotive parts, and household appliances have advised that they use the same procedure as on types 302 or 301. In some cases they have found the strip product to develop a high finish more easily. However, the author feels this is a function of the strip mill finish and can vary slightly with different production runs.

The difference in color is very minor and it is very difficult to distinguish any distinctive variation between these steels and types 301 and 302, when polished to a high finish on the same setup. This has also been noted on weld polishing where type 302 rod was used on type 202 sheet and plate stock.

Electrolytic polishing is very satisfactory; however with some types of baths a minor change in temperature is required.

Welding

Welding operations on types 201 and 202 have been accomplished with the same procedure as on their counterparts types 301 and 302. Service results have been obtained on spot, seam and projection welding, metallic arc, and heliarc fusion welding. Soundness of welds is equal, as are the shear, tension, and impact properties.

Beer barrels and milk cans have been welded from these steels using the same procedures and setup with both auto-

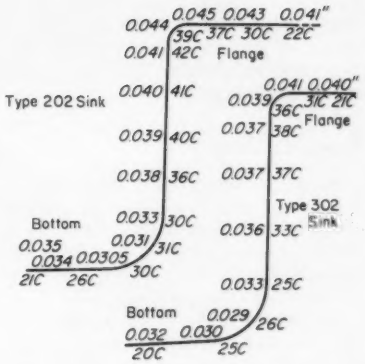


Fig. 3.—Hardness and Gage Surveys. Hardness is Rockwell C, and Gage is in Inches.

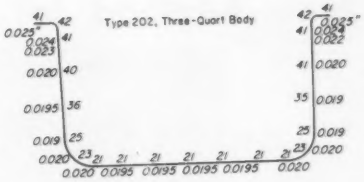


Fig. 4.—Cross-section of 3-qt Sauce Pan Made from Type 201. Hardness is Rockwell C, Converted from A, and Gage is in Inches.

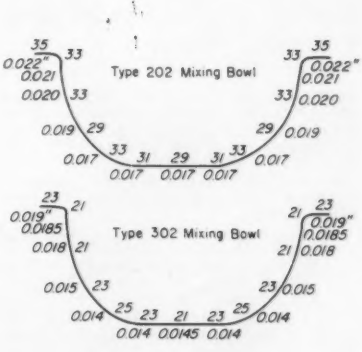


Fig. 5.—Comparable Sections of Types 202 and 302 Mixing Bowls. Hardness is Rockwell C, Converted from A, and Gage is in Inches.

matic and manual heliarc fusion welds. Regular type 304 rod can be used for repair or patch fill-in. Pressure and drop tests on assembled units are equal for comparable gage.

Stress Cracking

In the Republic Steel laboratory, a boiling 10 molar solution of lithium chloride has been standardized as a check for determining residual stress and susceptibility to stress cracking on chromium nickel stainless steels.

During the past six months numerous drawn samples have been checked, such as sinks, cooking utensils, and automotive parts for stress cracking. Comparative samples of types 201, 202, and 302 were drawn at the same time on the same dies. After testing, no difference was noted as to cracking; however, in most cases type 202 was slightly higher in hardness and more magnetic than type 302. Design, section, and rate of press action can be a factor in this characteristic and should be checked on individual items until a complete history is developed. At present it appears that both types of steel have at least approximately equal reaction to stress absorption and distribution with possibly more favorable condition on the types 201 and 202.

Summary

In concluding, the production and fabrication of AISI types 201 and 202 can be summarized as follows:

Melting of these steels has developed no problems other than changing melting practice to meet the desired chemistry. However, the conversion of ingot to sheet and strip product is more time consuming. More power is required for hot and cold rolling. This presents a special problem where ingot or slab sizes approach power limits of the blooming mill or hot strip mill. Annealing, pickling and cold rolling practices must be changed to produce commercial quality strip and sheet product.

Fabrication promotes no great problem; however, in deep drawing and spinning, changes must be made in tool design, power, and blank size.

New Method for Recording Explosion Impulse Effects on Solids

By W. E. BRON, K. A. ZADWICK, and A. L. TARR

A method of measuring properties of elastic waves as propagated in metals and generated by explosives or other means, using strain gages, amplifiers, and an oscilloscope for recording, is useful in experimenting with brittle failures

PROGRESS on the subject of impulse loading of solids, with particular emphasis on metals, has been extensively reviewed.[1] This paper describes a new method for the instantaneous recording of transient, elastic waves propagated through a metallic bar as the result of the detonation of an explosive at one end of the bar. The Hopkinson's bar[2] approach for the analysis of elastic wave forms as employed by Rinehart[3,4] is circumvented by the new method.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the authors. Address all communications to ASTM Headquarters, 1916 Race St , Philadelphia 3, Pa.

[1] J. S. Rinehart and J. Pearson, "Behavior of Metals Under Impulse Loads," Am. Soc. Metals (1954).

[2] B. Hopkinson, "A Method of Measuring the Pressure Produced in the Detonation of High Explosives or by Impulse of Bullets," *Transactions*, Royal Soc. (London), Vol. 213A, p. 437 (1914).

[3] J. S. Rinehart and J. Pearson, "Engravement of Transient Stress Wave Particle Velocities," *Journal of Applied Physics*, Vol. 24, p. 462 (1953).

[4] J. S. Rinehart, "Some Experimental Indications of the Stresses Produced in a Body by an Exploding Charge," *Journal of Applied Physics*, Vol. 22, p. 1178 (1951).

WALTER E. BRON, completing work toward a Ph.D. in metallurgy at Columbia Univ., New York City, as the William Campbell Fellow in Metallurgy, was in the U. S. Army stationed at the Engineer Research and Development Laboratories, at Ft. Belvoir, Va., when the work on impulse loading was performed.

KENNETH A. ZADWICK, with a degree in food engineering from Illinois Institute of Technology, was assigned by the Army to ERDL, where he has been engaged in instrumentation problems in nuclear detection and evaluation of scintillation crystals, engine test, and on explosive loading.

ALLAN L. TARR, consulting metallurgist, ERDL, U. S. Army, has been a professional metallurgist since 1928, is the author of several patents and technical papers on a wide range of subjects, and initiated the explosive impulse studies in connection with attempts to obtain criteria for the diagnosis of brittle failures of military equipment.

Plane elastic waves were propagated axially along metallic bars through the detonation of specially designed, plane-wave generating explosives. The elastic wave was transmitted to SR-4 strain gages placed along the axis of the bar. The resulting signal was amplified, displayed on an oscilloscope screen, and photographed.

Experimental Apparatus

The arrangement of the circuit for a single strain gage is shown in Fig. 1. The Hewlett and Packard type 460A amplifiers were modified to obtain additional filtering so as to prevent leakage of 60-cycle voltage to the oscilloscope. Extensive shielding at the input end of the system was necessary to eliminate the pickup of stray 60-cycle fields from nearby power lines. The filter shown in Fig. 1 was used to eliminate any residual 60-cycle voltage. In order to insure proper operation of the circuit it is necessary for all lines to be terminated with the proper matching load. An artificial pulse was injected to check the operation of the assembled system.

A Fairchild Polaroid Camera, type F286, was employed to obtain a permanent recording of the data. The camera was operated open-shutter and used Pola Pan, type 44 film. The combination possesses a writing speed in excess of 12 in. per microsecond.

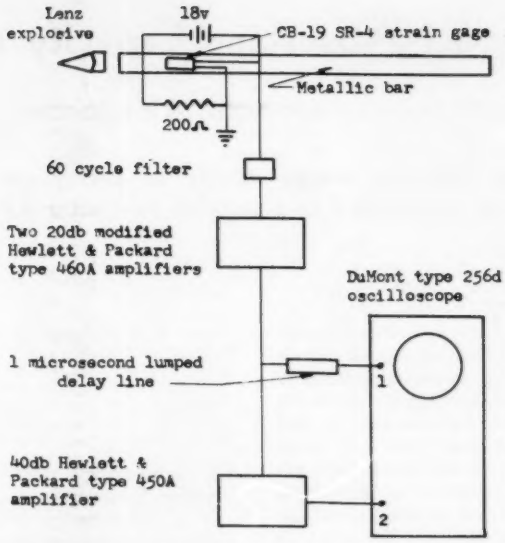
The scope face was independently calibrated: the time base by movement of a marker controlled by a multiturn "delay" potentiometer in increments of 0.2 microsecond, and the amplitude with a calibrated sine wave generator. Conversion of voltage amplitude to static strain amplitude is accomplished through strain gage calibration. The strain gage was applied to the rods using a standard method of baking.

Figure 2 is a photograph of a transient elastic wave in a base of SAE 1020 steel. The maximum amplitude in the photograph represents a strain of 0.006 in. per in.; the rise time of the system, which is limited only by the strain gage, is approximately 0.3 microsecond. The modulation of the decay portion of the pulse may be due to "ringing" in the preamplifier due to some mismatch in its termination, and to the partial non-planer characteristics of the explosive wave which results in reflections of part of the wave at the exterior surface of the bar.

Discussion of Results

The method enables the instantaneous and direct recording of elastic strain waves along the length of metallic bars.

[5] J. S. Rinehart, "Some Quantitative Data Bearing on the Scabbing of Metals Under Explosive Attack," *Journal of Applied Physics*, Vol. 22, p. 555 (1951).



NOTE.—Position No. 1 on the oscilloscope is the input to the video amplifier; Position No. 2 is the trigger input.

Fig. 1.—Circuit Arrangement of Apparatus for Recording Elastic Wave Propagation Through Metallic Bars.

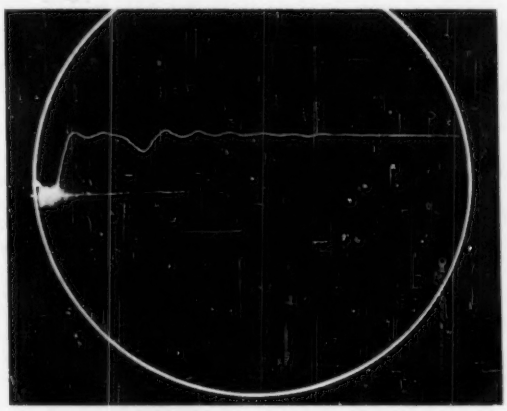


Fig. 2.—Reproduction of the Oscilloscope Trace,Using 4 U. S. Sweep Showing the Transient Elastic Wave in an SAE 1020 Bar.

If simultaneous recordings are made at several strain gages along the axis of the bar, determination of the following parameters of propagation is possible:

1. Propagation velocity of the wave.
2. Change in shape of the wave form as a function of displacement down the bar. Included in this is the decay of the maximum strain, changes in the rise time, and changes in decay characteristics.
3. Propagation of elastic waves as a function of strain amplitude.
4. Reflection characteristics of the elastic waves at the free ends of the bar.

Item 4 is important to the understanding of the scabbing phenomenon[5] and accurate determination of the above four items should make the location of the scabbing site predictable.

Acknowledgment:

The authors wish to express their appreciation to the Mine Warfare Branch of Engineer Research and Development Laboratories for the contribution of funds to support this endeavor, and to Roger France, and Lt. R. Hatfield, The Engineer School, for their kind advice.

The Impact-Absorbing Capacity of Textile Yarns*

By J. C. SMITH, F. L. McCRACKIN, and H. F. SCHIEFER

The limiting breaking energy density or energy per gram of yarn required for an immediate impact break is suggested as a suitable parameter for characterizing the impact-absorbing property

THE capacity of textile yarns for withstanding impact stresses is a topic of increasing importance in modern living. Tire cords, seat belts, safety lines, parachute shroud lines, and thread for high-speed sewing machines are some of the applications in which impact-absorbing capacity is important. Impact speeds involved in these applications range up to 70 m per sec (150 mph). For speeds of this magnitude special techniques are necessary for studying impact behavior. Some techniques used by the authors, and some typical results with their interpretation form the body of this paper.

The Characterization of Impact-Absorbing Capacity

If one end of a textile yarn is given an impact velocity, v, a longitudinal strain wave, ϵ, is propagated down the yarn with velocity C. In time, t, the wave front travels a distance, Ct, and the end of the yarn moves a distance, vt. Thus a length, Ct, of yarn is stretched an amount, vt, and:

$$\epsilon = \frac{v}{C} \quad \ldots\ldots\ldots\ldots (1)$$

The stress, σ, in the yarn is given by:

$$\sigma = E\epsilon \quad \ldots\ldots\ldots\ldots (2)$$

where E is Young's modulus. This stress is also equal to the time rate of change of momentum of unit cross-section resulting from the propagation of the wave. As a length of yarn, Ct, is given a velocity v in time t, this rate of change of momentum per unit cross-section is $\rho Cvt/t$. Thus:

$$\sigma = \rho Cv \quad \ldots\ldots\ldots\ldots (3)$$

where ρ is the density of the yarn. Equations 2 and 3 give, with the help of Eq 1:

$$C = \sqrt{\frac{E}{\rho}} \quad \ldots\ldots\ldots\ldots (4)$$

The preceding analysis assumes Hookean behavior.

If a high-tenacity nylon yarn (for which according to recent measurements, C is 2500 m per sec) is impacted at velocity 70 m per sec, the resulting wave strain is $70/2500 = 0.028$. As the breaking strain is approximately 0.15, it is seen that a free nylon yarn can esaily withstand this impact. The wave strain for Fiberglas (C = 3500 m per sec) impacted at the same velocity is $70/3500 = 0.02$, which is close to the breaking strain. A free Fiberglas yarn, then, impacted at 70 m per sec is likely to break immediately upon impact.

It appears from these examples that breaking elongation of the yarn is an important factor to be considered in evaluating impact-absorbing capacity. However, tenacity or breaking strength of the yarn is also important. High-strength in textile yarns is usually associated with a high modulus which, from Eq 4, means that the wave propagation velocity, C, will be high. From Eq 1 it follows then that the strain in the wave, ϵ, will be low. A parameter for evaluating impact-absorbing capacity must therefore be a function of both breaking strength and breaking elongation. Limiting breaking energy density

JACK C. SMITH joined the National Bureau of Standards in 1954 as project leader of the experimental and theoretical work on stress wave propagation phenomena in fibrous materials, the effects of high energy radiation on polymers, and the electrical properties of textiles at very low temperatures and relative humidities.

FRANK L. McCRACKIN is project leader at the National Bureau of Standards investigating high-temperature creep behavior of aircraft plastics. Since 1953 he has concentrated on theoretical analysis of stress-strain phenomena in fibrous materials subjected to rapid impact loading as part of his doctoral dissertation.

HERBERT F. SCHIEFER has been research physicist with the National Bureau of Standards since 1929 and has been active in ASTM Committee D-13 on Textiles for many years. He has developed new textile testing instruments and methods and his pioneering work in the evaluation of the mechanical properties of textiles has gained him an international reputation.

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* This paper was presented at the Symposium on Rheology of the June, 1956 meeting of the Society of Rheology and the 59th Annual Meeting of ASTM. Permission to publish this paper has been granted by the Quartermaster Research and Development Command, U. S. Army, which sponsored and supported this work as part of a broad and long-term program of research.

is proposed as an appropriate parameter for this purpose. This quantity is the amount of work per unit mass of yarn that is expended on a specimen impacted at a velocity just sufficient to cause immediate[1] rupture. If the stress-strain curve to rupture were known for a textile yarn tested under these conditions, the limiting breaking energy density would be proportional to the area under this curve.

In the usual methods for obtaining stress-strain curves, the force is measured at one end of a specimen while it is being elongated. The strain at a point in a specimen increases by increments as the strain wave propagates back and forth. At ordinary speeds, these increments are small and the strain in the specimen can be represented by the average strain, which is the quantity measured. This situation no longer holds at higher impact speeds where the strain wave becomes large in magnitude. Similarly, at high speeds the force measured at one end of the specimen increases by large increments, and the stress-strain curve consequently takes on a jagged appearance. The usual method of obtaining stress-strain curves thus becomes increasingly inaccurate when the extension velocity exceeds approximately 50 m per sec.

In practice, limiting breaking energy densities are estimated by integrating under the stress-strain curve up to the rupture strain, using a curve obtained at the highest rate of extension practicable. This procedure assumes that the curve used does not differ much from the stress-strain curve applicable for a specimen tested at an extension rate just sufficient to cause an immediate impact break.

Breaking energy densities can also be found by other methods. One could, for instance, measure the kinetic energy lost by a moving mass which impacts one end of a textile yarn. A method of this type is described later in this paper.

If a material obeying Hooke's law is extended to a rupture strain ϵ_r, the breaking energy per unit volume is given by

$$w_r = \tfrac{1}{2} E \epsilon_r^2 \quad \ldots\ldots\ldots (5)$$

If v_b is the longitudinal impact velocity just sufficient to produce immediate rupture in a Hookean material, we also have upon substituting:

$$\epsilon_b^2 = \frac{v_b^2}{C^2} = \frac{\rho v_b^2}{E}$$

$$w_b = \tfrac{1}{2} \rho v_b^2 \quad \ldots\ldots\ldots (6)$$

where ϵ_b and w_b are the special values of ϵ_r and w_r obtained at impact velocity v_b. In Eq 6 if the units of v_b are cm per sec and of ρ are g per cu cm, w_b is expressed in ergs per cu cm. However, it is customary with textiles to use unit mass rather than unit volume as a reference. A more useful form for Eq 6 would then be

$$w_b \text{ (joules per g)} = \tfrac{1}{2} v_b^2 \times 10^{-7} \quad \ldots (6a)$$

A common unit of textile fineness is the denier or mass in grams of 9000 m of yarn. If a 1-denier yarn, 1 m long, is used as the mass unit and gram-centimeter as the work unit, Eq 6(a) can be converted to these new units by the relation, w_b expressed in gram-centimeter per meter-denier = $1.134 w_b$ expressed in joules per gram.[2]

If W_b signifies the limiting breaking energy density for any textile yarn,[3] for which in general Hooke's law is not applicable, the equation.

$$W_b = \tfrac{1}{2} \rho V_b^2 \quad \ldots\ldots\ldots (6b)$$

suggested by the preceding discussion can be used to define a quantity V_b called the limiting breaking velocity. This characteristic velocity, discussed in a previous publication (**2**),[4] approximates the longitudinal impact velocity just sufficient to cause immediate rupture.

Von Karman (**6**) has published a theory of the effect of tensile impact upon long filaments. This theory takes into account the non-Hookean nature of the material impacted provided that the shape of the stress-strain curve is not concave upward and does not depend upon the rate of straining. Stress-strain curves for textile fibers do depend upon the rate of straining, but the effect on the theory of this dependence is minimized if a curve obtained at a high straining rate is used. Stress-strain curves for textile fibers usually have a concave upward portion. However, this effect is less pronounced in the curves obtained at high staining rates. Thus von Karman's theory may be expected to give good predictions of textile fiber impact behavior when used in conjunction with a stress-strain curve obtained at a high testing rate.

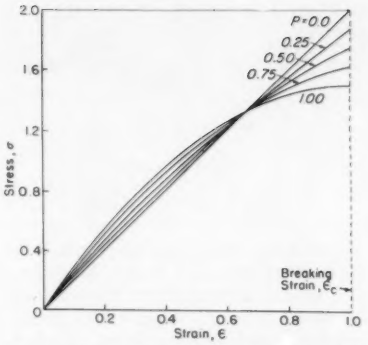

Fig. 1.—Stress-Strain Curves for Materials Having the Same Limiting Breaking Velocity, Energy to Rupture, and the Same Breaking Strain, but Different Critical Velocities, Plotted for Different Values of the Shape Parameter, p.

According to von Karman's theory there exists a critical velocity, V_c, which is just sufficient to produce immediate rupture upon tensile impact. This critical velocity is given by:

$$V_c = \int_0^{\epsilon_c} \sqrt{\frac{1}{\rho} \frac{d\sigma}{d\epsilon}}\, d\epsilon \quad \ldots\ldots (7)$$

where ϵ_c is the breaking strain of the material when impacted at the critical velocity.

Limiting breaking velocity in accordance with the preceding discussion may be defined as:

$$V_b = \sqrt{\frac{2}{\rho} W_b} = \sqrt{\frac{2}{\rho} \int_0^{\epsilon_c} \sigma d\epsilon} \quad \ldots (8)$$

Thus it is seen that critical velocity, V_c, depends upon the shape of the stress-strain curve, whereas the limiting breaking velocity, V_b, depends upon the area under it. When the stress-strain curve is a straight line, V_b and V_c are the same and are equal to $\epsilon_c \sqrt{E/\rho}$. In general, however, V_c is less than V_b by an amount depending upon the shape of the stress-strain curve. As an example of this difference between V_c and V_b, consider a family of parabolic stress-strain curves of different shape but such that the limiting breaking energy density and the rupture strain associated with each curve are the same. That is, for each curve the following conditions hold:

$$\left.\begin{aligned} \int_0^{\epsilon_c} \sigma d\epsilon = W_b = \text{constant} \\ \epsilon_c = \text{constant} \end{aligned}\right\} \quad \ldots (9)$$

This family is given by:

$$\sigma = (p+2) \frac{W_b}{\epsilon_c^2} \epsilon - \frac{3}{2} p \frac{W_b}{\epsilon_c^3} \epsilon^2 \quad \ldots (10)$$

where p is a parameter assuming numerical values between 0 and 1. When p is zero the curve is a straight line. When p is unity the curve is a parabola having zero slope at the rupture strain, ϵ_c. Figure 1 gives a plot of the curves corresponding to several values of the parameter p.

---

[1] "Immediate" in the sense used here means that the breaking strain is achieved in the original strain wave resulting from the impact. Immediate rupture is to be distinguished from rupture that occurs when the breaking strain results from a reflection of the strain wave.

[2] In accordance with practice in the textile industry force will be expressed in grams-weight, and "cross-section" in denier giving "stress" in grams per denier.

[3] The capital letters W_b and V_b will be used when referring to yarns in general. The small letters w_b and v_b are used only when Hooke's law applies. Note that V_b designates the limiting breaking velocity, which in general is not the same as the tensile impact velocity just sufficient to cause an immediate impact break.

[4] The boldface numbers in parentheses refer to the list of references appended to this paper.

Substituting σ from Eq 10 into Eq 7 for V_c and using the definition 8 for V_b in conjunction with the relation 9 gives:

$$V_c = V_b f(p) \quad \ldots\ldots\ldots (11)$$

where $f(p)$ is given by

$$f(p) = \frac{4}{9p}\left[\left(1 + \frac{p}{2}\right)^{3/2} - (1 - p)^{3/2}\right] \quad \ldots (12)$$

In Table I values of $f(p)$ are given that correspond to the same parameter values used for the curves plotted in Fig. 1. These values indicate that the velocity just sufficient to cause immediate tensile impact break (according to von Karman) is less than the limiting breaking velocity computed from the limiting breaking energy density.

The ideas expressed in this section may now be summarized. The capacity of a textile yarn to absorb a tensile impact may be characterized by its limiting breaking energy density W_b. This quantity is the work per unit mass of yarn that is expended when the yarn is subjected to tensile impact at a velocity just sufficient to cause an immediate breakage. Usually W_b is taken as the limiting value of a series of breaking energy densities W_r measured at lower impact speeds. The concept of a tensile impact velocity that is just sufficient to cause an immediate impact break has been introduced by von Karman, who terms it the critical velocity, V_c. The value of V_c depends upon the shape of the stress-strain curve. The limiting breaking velocity, V_b, which is computed from the limiting breaking energy density approximates the critical velocity, V_c. Usually V_b is greater than V_c, but when the stress-strain curve is linear, these two velocities are equal.

Methods for Measuring Limiting Breaking Energy Density

Longitudinal Impact Test

If a yarn specimen to which head and tail masses are attached is rapidly elongated by impacting the head mass, a head mass velocity, V_{mn}, can be found that is just sufficient to cause rupture. Breaking energy density, W_{mn}, can then be calculated using the formula:

$$W_{mn} = \frac{1}{2}\frac{(n + \frac{1}{2})(m + \frac{1}{2})}{n + m + 1} V_{mn}^2 \quad \ldots (13)$$

where:

n = ratio of the tail mass to the mass of the specimen,

m = ratio of the head mass to the mass of the specimen, and

V_{mn} = velocity of the head mass after impact, that is just sufficient to rupture the specimen.

[1] A Lagrangian system of coordinates is fixed to the specimen, moving and extending with it.

TABLE I.—RATIO OF CRITICAL VELOCITY TO LIMITING BREAKING VELOCITY, $f(p)$, AS A FUNCTION OF THE STRESS-STRAIN CURVE SHAPE PARAMETER, p.

p	$f(p)$
0.00	1.00
0.25	0.97
0.50	0.93
0.75	0.88
1.00	0.82

A derivation neglecting wave effects is given for this formula in the Appendix.

A number of breaking energy densities are found from experiments with specimens to which different head and tail masses are attached. If these values of W_{mn} are found to be independent of the impact velocity over a sufficiently large range, the average is taken and assumed to be equal to the limiting breaking energy density W_b.

When the quantity $[(n + \frac{1}{2})(m + \frac{1}{2})]/(n + m + 1)$ is less than 40, Eq 13 becomes unreliable for approximating breaking energy density. This happens because the strain wave amplitude in the specimen, for impact velocity V_{mn} becomes larger as

$$\frac{[(n + \frac{1}{2})(m + \frac{1}{2})]}{(n + m + 1)}$$

decreases. Thus the rupture strain, which is attained when the strain wave is reflected at the head or tail mass, becomes increasingly uncertain. This uncertainty affects the validity of the derivation of Eq. 13. Therefore in determining the breaking energy densities by this method the highest impact velocity V_{mn} that can be used is approximately $1/\sqrt{40}$ or $\frac{1}{6}$ of the limiting breaking velocity. Ideally the limiting breaking velocity should be determined directly by impacting a specimen to which no tail mass is attached. However the speeds required usually exceed those possible with the apparatus available.

The apparatus used for the measurements reported here has been described and the associated theory discussed at length in previous publications (**1**,**2**,**3**).

Breaking energy density can also be estimated from stress-strain data obtained by impacting yarn specimens transversely. The procedure is to impact a clamped yarn segment at the midpoint and to photograph the successive configurations of the yarn up to rupture by means of a high-speed camera. The series of pictures obtained provide sufficient data to compute the stress-strain curve.

Transverse Impact Test

When a yarn is struck transversely by a projectile traveling at velocity V, a longitudinal strain wave is propagated along the yarn with velocity, C, outward in each direction from the point of impact. In the region between these wave fronts the material of the yarn is set in motion toward the point of impact. This inward flowing material forms itself into a tent-shaped wave with the impacting projectile at the vertex. The base of the tent propagates outward as a transverse wave with velocity U.

The velocity, U, is a function of the tension, T, and strain, ϵ, in the yarn in the region of the transverse wave front, and of the mass per unit length, M, of the unstrained yarn. This relationship is given by:

$$U = \sqrt{\frac{T}{M(1 + \epsilon)}} \quad \ldots\ldots (14)$$

where U is in Lagrangian coordinates.[5] The transverse wave propagates more slowly than the longitudinal strain wave.

When the yarn specimen is clamped at two points equidistant from the point of impact, reflections of the longitudinal strain wave and also of the transverse wave will occur at the clamp and at the projectile. At these reflections the local strain increases by finite increments which are small for suitably small impact velocities V. The principal effects noted in a test are the increase in velocity, U, as the strain increases, and the change in configuration of the specimen as the transverse wave is reflected at the clamps and at the projectile.

The length of the yarn segment from the impact point to one of the clamps is measured in each frame of the photographic record. As the average strain in the specimen $\bar{\epsilon}$ is equal to the increase in length divided by the original length, the complete strain-time history of the specimen can be determined. From measurements of the position of the transverse wave front in each frame it is possible to construct a position-time curve. By measuring slopes of this curve the velocity of the transverse wave can be found as a function of time. Substitution of the velocities U, and strains $\bar{\epsilon}$, for each frame into Eq 14 gives the tension per unit mass. In order to express the tension in appropriate textile units the following formula can be used.

$$T = 1.134 \times 10^{-9}\, U^2 (1 + \bar{\epsilon}) \quad \ldots (15)$$

In this formula U (corrected to a Lagrangian coordinate system) is expressed in centimeters per second, and $\bar{\epsilon}$ as a fraction of unity. T, then, is given in grams per denier.

Apparatus for obtaining the data required by the method just described has been constructed, and measurements have been made on a number of textile yarns. Experience with this apparatus indicates that satisfactory

TABLE II.—TENACITIES, ELONGATIONS, AND BREAKING ENERGY DENSITIES FOR SOME TEXTILE MATERIALS.

Material	Type of Test	Rate of Straining, per cent per min	Elongation at Break, per cent	Tenacity at Break, g per denier	Breaking Energy Density	
					g-cm per m-denier	joules per g
High Tenacity Nylon	slow speed	1	16.7	6.28	41.3	36.4
	slow speed	10	17.6	6.76	50.1	44.2
	slow speed	100	16.1	6.97	46.2	40.7
	transverse impact 50 m per sec	300 000 (5 000 %/sec)	14.7	7.57	43.8	38.6
	longitudinal impact 50 m per sec	400 000 (7 000 %/sec)	...	...	32.7	28.8
Fortisan	slow speed	1	5.4	6.33	17.6	15.5
	slow speed	10	5.4	6.80	19.3	17.0
	slow speed	100	5.3	7.04	20.4	18.0
	transverse impact 50 m per sec	120 000 (2 000 %/sec)	5.2	9.10	25.0	22.0
	longitudinal impact 40 m per sec	350 000 (6 000 %/sec)	...	...	18.0	15.8
Fiberglas	slow speed	1	2.8	4.73	7.6	6.7
	slow speed	10	2.5	5.58	7.5	6.6
	slow speed	100	2.4	6.07	7.7	6.8
	transverse impact 50 m per sec	60 000 (1 000 %/sec)	1.8	6.12	5.1	4.5
	longitudinal impact 20 m per sec	2000 000 (3 000 %/sec)	...	...	5.1[a]	4.5[a]

[a] Tentative value should be checked by further tests.

stress-strain curves can be obtained when a 60-cm clamped specimen is impacted at the midpoint with velocity 50 m per sec. The rate of straining as computed from breaking elongation and breaking time is of the order of 5000 per cent per sec. If much higher impact speeds are used in a test, the strain wave magnitudes become sufficiently great to cause uncertainties in the method. The apparatus used and the data analysis for this method have been described in previous publications (4,5,7).

Description of Samples Tested

The samples tested are identified as follows:

1. High Tenacity Nylon.—DuPont, type 300, 5 ply, 210 denier per ply, 3 Z twist, 1085 denier total, obtained from Quartermaster Research and Development Command, U. S. Army.
2. Fortisan.—High tenacity deacetylated cellulose acetate yarn, 3 ply, 270 denier per ply, 2 Z twist, 787 denier total, obtained from Celanese Corporation of America.
3. Fiberglas.—Type 150—1/0, 204 filament, 1 Z twist, 323 denier, obtained from Owens-Corning Fiberglas Corporation.

Test Results

Samples of the nylon, Fortisan, and Fiberglas yarns were tested at various rates of straining. Breaking energy densities obtained from these tests are given in Table II. Stress-strain curves used in computing breaking energy densities for the slow speed tests and transverse impact tests are shown in Figs. 2, 3, and 4.

The data for nylon indicate that when nylon is impacted longitudinally at 50 m per sec the breaking energy density becomes approximately 25 per cent less than the slow speed value. The value of 38.6 joules per g obtained from the transverse impact tests seems high. This may be due to an overestimate of the breaking elongation. For a breaking elongation of 13.0 per cent, rather than the 14.7 per cent given, the breaking energy density would be 30.4 joules per g.

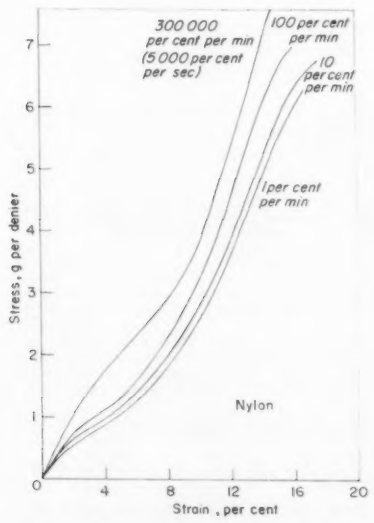
300 000 per cent per min (5 000 per cent per sec)
100 per cent per min
10 per cent per min
1 per cent per min
Nylon
Stress, g per denier
Strain, per cent

Fig. 2.—Stress-Strain Curves to Rupture for Nylon at Various Rates of Straining.

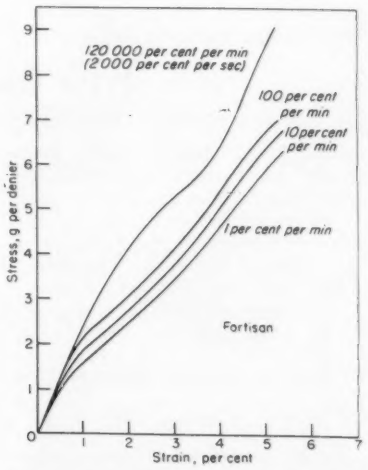
120 000 per cent per min (2 000 per cent per sec)
100 per cent per min
10 per cent per min
1 per cent per min
Fortisan
Stress, g per denier
Strain, per cent

Fig. 3.—Stress-Strain Curves to Rupture for Fortisan at Various Rates of Straining.

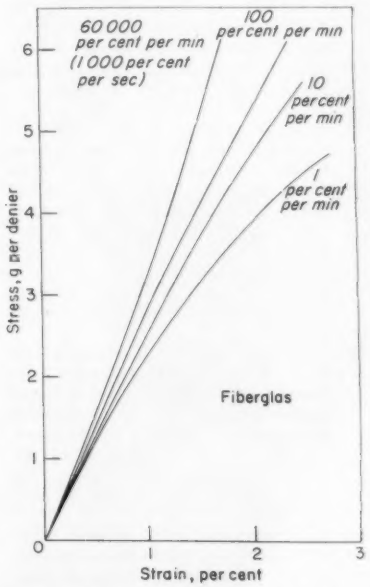
60 000 per cent per min (1 000 per cent per sec)
100 per cent per min
10 per cent per min
1 per cent per min
Fiberglas
Stress, g per denier
Strain, per cent

Fig. 4.—Stress-Strain Curves to Rupture for Fiberglas at Various Rates of Straining.

The impact behavior for the nylon sample tested was measured for longitudinal impact speeds up to 50 m per sec. If it is assumed that the breaking energy density of 28.8 joules per g for 50 m per sec impact does not decrease further at higher longitudinal impact speeds, a limiting breaking velocity of 240 m per sec is obtained from a calculation using Eq 6b. The critical velocity is probably a little less than this value.

In the case of Fortisan the breaking energy density remains approximately the same for a range of longitudinal impact speeds up to 40 m per sec. If the 15.8 joules per g value given for this latter speed is taken as the limiting breaking energy density, an associated limiting breaking velocity of 178 m per sec is found by calculation. The breaking energy density value given by the transverse impact tests again seems high.

Breaking energy densities for Fiberglas appear to decrease slightly at high longitudinal impact speeds. If 4.5 joules per g is taken as the limiting breaking energy density, the limiting breaking velocity calculates out to be 95 m per sec.

The three yarn samples tested all have high tenacities. However, the abilities of these yarns to absorb tensile impacts vary appreciably, nylon appears to be best in this respect; Fiberglas, poorest.

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(2) F. L. McCrackin, H. F. Schiefer, J. C. Smith, and W. K. Stone, "Stress-Strain Relationships in Yarns Subjected to Rapid Impact Loading. 2. Breaking Velocities, Strain Energies, and Theory Neglecting Wave Propagation," *Journal of Research*, Nat. Bureau of Standards, Vol. 54, No. 5, May, 1955, p. 277. *Textile Research Journal*, Vol. 25, No. 6, June, 1955, p. 529.

(3) J. C. Smith, F. L. McCrackin, and H. F. Schiefer, "Stress-Strain Relationships in Yarns Subjected to Rapid Impact Loading. 3. Effect of Wave Propagation," *Journal of Research*, Nat. Bureau of Standards, Vol. 55, No. 1, July, 1955, p. 19. *Textile Research Journal*, Vol. 25, No. 8, Aug. 1955, p. 701.

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(7) J. C. Smith, F. L. McCrackin, H. F. Schiefer, W. K. Stone, and K. M. Towne, "Stress-Strain Relationships in Yarns Subjected to Rapid Impact Loading. 4. Transverse Impact Tests," *Journal of Research*, Nat. Bureau of Standards, Vol. 57, No. 2, Aug., 1956, p. 83. *Textile Research Journal*, Vol. 26, No. 11, Nov., 1956, p. 821.

APPENDIX

Derivation of Eq 13

Consider a yarn specimen of mass w, to which is attached a head mass mw, and a tail mass nw. Let the head mass be given an initial velocity V by a tensile impact. As a result of this impact, the specimen will be elongated, the head velocity will decrease, and the tail velocity will increase. The velocity, V', of the center of mass, is given by:

$$V' = \frac{m + \frac{1}{2}}{m + n + 1} V \qquad \text{(A1)}$$

This velocity is found by equating the initial momentum of the head mass to the momentum of the system. It is assumed that half of the mass of the specimen is concentrated at the head and half at the tail, and that the impact velocity is such that wave propagation effects can be neglected [**2,3**].

At the instant the specimen attains its maximum elongation, the head velocity, tail velocity, and velocity of the center of mass are all the same [**2**]. There exists an initial head velocity V_{mn} such that the specimen breaks at the instant this maximum elongation occurs. To find V_{mn} experimentally it is only necessary to determine the lowest impact velocity for a given m and n at which rupture occurs. When the yarn specimen is impacted at velocity V_{mn}, the energy required to break it is equal to the kinetic energy lost by the head mass minus the kinetic energy gained by the tail mass.

The initial kinetic energy of the head mass is:

$$\tfrac{1}{2} w(m + \tfrac{1}{2}) V_{mn}^2$$

The final kinetic energy of the head mass is,

$$\frac{1}{2} w \left(m + \frac{1}{2}\right) \frac{(m + \frac{1}{2})^2}{(m + n + 1)^2} V_{mn}^2$$

so that the energy lost by the head mass is,

$$\frac{1}{2} w \left(m + \frac{1}{2}\right)\left[1 - \frac{(m + \frac{1}{2})^2}{(m + n + 1)^2}\right] V_{mn}^2$$

The energy gained by the tail mass is:

$$\frac{1}{2} w \left(n + \frac{1}{2}\right) \frac{(m + \frac{1}{2})^2}{(m + n + 1)^2} V_{mn}^2$$

The work required to break the specimen, then, is

$$\frac{1}{2} w \left[\left(m + \frac{1}{2}\right) - \left(m + \frac{1}{2}\right)\frac{(m + \frac{1}{2})^2}{(m + n + 1)^2} - \left(n + \frac{1}{2}\right)\frac{(m + \frac{1}{2})^2}{(m + n + 1)^2}\right] V_{mn}^2$$

or

$$\frac{1}{2} w \left(m + \frac{1}{2}\right)\left[1 - \frac{(m + \frac{1}{2})}{m + n + 1}\right] V_{mn}^2$$

or

$$\frac{1}{2} w \frac{(m + \frac{1}{2})(n + \frac{1}{2})}{m + n + 1} V_{mn}^2$$

The breaking energy density or work per unit mass is therefore given by:

$$W_{mn} = \frac{1}{2} \frac{(m + \frac{1}{2})(n + \frac{1}{2})}{m + n + 1} V_{mn}^2 \qquad \text{(A2)}$$

The rationale of this derivation is discussed more completely in an earlier paper (**2**). Reasons for the assumption that half the mass of the specimen is concentrated at the head and half at the tail are given in an earlier paper (**3**).

Measurement of Cure Rate of Thermosetting Molding Materials

By A. J. GUZZETTI

The cure speeds of thermosetting materials may be estimated from the rigidity of hot molded pieces immediately upon discharge from the mold with results expressed as an apparent modulus of elasticity

PRODUCT descriptions, as prepared by plastics raw materials' suppliers, represent an invaluable source of information and guidance for the end-product fabricator. A typical data sheet usually lists quantitatively the physical, chemical, and electrical properties that may be expected with a given compound. However complete this information may be on a specific property, these data sheets on numerous occasions will treat equally important properties in terms of mere qualitative statements. Such has been the case in describing the rate of cure of phenolic molding materials. Phrases such as "very fast hardening rate" or "relatively slow rate of cure" have been presumed to describe the behavior of a material under all molding conditions. This, of course, is not the case.

To the fabricator, speed of cure usually means the time required to produce a molding which is:

1. Sufficiently rigid:
   (*a*) so as not to strip prematurely over undercuts designed to hold it in one or the other mold half, or
   (*b*) so as not to distort unduly during ejection and subsequent handling before it is cold
2. Free from undercure blisters caused by entrapped air, water vapor, or volatile matter formed during cure.

It would be advantageous to the molder if he could, even partially, estimate this time requirement based on readily available quantitative information.

A practical method is necessary to determine or define the progress of the thermosetting reaction, the results of which should be presented in terms of properties that are of practical significance with respect to resin manufacture, molding technique, or final molded product. Toward this end, various methods of measurement (1–30)[1] have been employed, including:

1. Reduction in electrical conductivity
2. Reduction in solvent extractables, or in swelling by solvents
3. Increase in water resistance
4. Attenuation and change in velocity of ultrasonic vibrations
5. Increase in ultimate strength
6. Elimination of under-cure blisters
7. Changes in rheological properties
   (*a*) flow properties
   (*b*) dynamic shear modulus and damping of molded pieces
   (*c*) rigidity of hot molded pieces
8. Increase in hardness of cured pieces
9. Chemical methods
   (*a*) labile formaldehyde of resols
   (*b*) "degree of reaction" of melamine-formaldehyde resins
   (*c*) hydroxyl content of silicone resins
   (*d*) oxyrane ring content of epoxies

Also, four ASTM test methods[2] provide results which are indicative of the degree of cure.

From the standpoint of practicality, changes in rheological properties present a desirable means of measuring cure speed. Flow properties, for instance, tell how the molding material will behave during manufacture and during molding—up to the point at which the material will no longer flow under given conditions. Beyond this range, and where the reaction has progressed to the point where the molding can be removed from the mold, hot rigidity appears to be the most informative measure of cure because:

1. Proper rigidity at time of discharge from the mold is an essential requirement for satisfactory molding performance. Insufficient rigidity results in distortion or release difficulties, and excessive rigidity may result in cracking of the piece during ejection.
2. Results of hot rigidity measurements can be expressed quantitatively in terms of a fundamental property.
3. Measurements may be rapidly made on hot molded pieces immediately after discharge from the mold before their properties have been significantly changed by further cure.
4. Rigidity measurements can be made on thermosetting molding materials in general.
5. Minimum time required to obtain a blister-free piece, while also a requirement for satisfactory molding (especially with materials that give off volatiles during cure) is partially dependent upon rigidity and is affected by factors unrelated to cure, such as molding variables which control de-gassing.

The measurement of hot rigidity of a molded piece is not new. Bakelite Co. has, for many years, employed a test that measures the rigidity of a standard test disk upon removal from the mold. This test has proved successful for quality control use. On the other hand, it is of limited utility for material characterization purposes, because the data obtainable lack absolute significance.

A new method, which yields precise measurements of the rigidity of hot moldings in terms of a more fundamental

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

[2] ASTM methods of test for:
Acetone Extraction of Phenolic Molded or Laminated Products (D 494 – 46), 1955 Book of ASTM Standards, Part 6, p. 375.
Water Absorption of Plastics (Tentative) (D 570 – 54 T), 1955 Book of ASTM Standards, Part 6, p. 362.
Heat Distortion Temperature of Plastics (Tentative) (D 648 – 45 T), 1955 Book of ASTM Standards, Part 6, p. 296.
Rockwell Hardness of Plastics and Electrical Insulating Materials (D 785 – 51), 1955 Book of ASTM Standards, Part 6, p. 247.

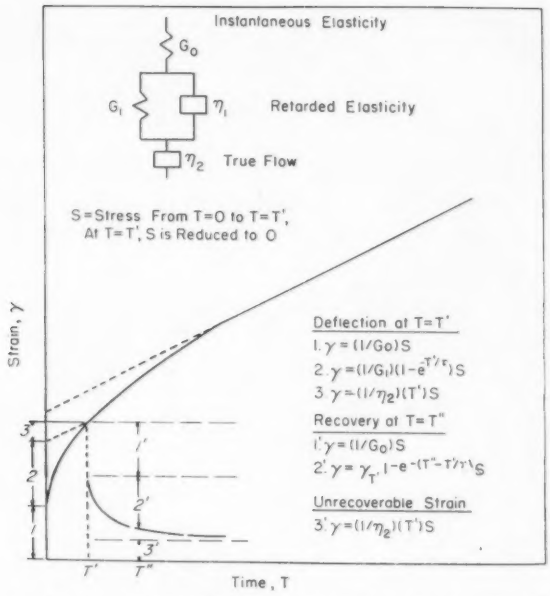

Fig. 1.—Behavior of Ideal Viscoelastic Material under Constant Stress.

property, and which is applicable to thermosetting molding compounds in general over a wide range of molding conditions, is the subject of this paper.

Summary of Method

A device for measuring the rigidity of hot thermoset moldings has been designed and put into operation. It consists of (1) a mold for producing bar specimens, and (2) a flexural testing chamber that is integral with and maintained at the same temperature as the mold. Thus, immediately upon ejection from the mold, the test specimen is rapidly slid into the chamber. Here, the specimen (in the form of a beam) is bent by means of a variable load mechanism. Specimen deflections are automatically recorded as a function of time. The rigidity of the hot specimen is expressed as an apparent modulus of elasticity through calculations using specimen dimensions, applied load, and deflection.

Hot thermosetting moldings, when subjected to stress, undergo retarded elastic deformations. Upon application of such stress, they exhibit rapid initial deformation and continue to deform at a diminishing rate for some time. To define completely the rheological properties of such pieces is practically impossible. On the other hand, an apparent modulus of elasticity may be rapidly and conveniently determined from deformations measured at a fixed time after application of a stress.

The curing reactions of various thermosetting materials may be followed, at constant temperature and pressure, by apparent modulus measurements on specimens cured over varying lengths of time. In all cases, modulus values increase at a diminishing rate with increasing cure time.

Investigations show that an increase in temperature produces opposing mechanisms with regard to rigidity. Higher temperatures tend to increase rigidity by accelerating the chemical curing reactions. In opposition, rising temperatures tend to reduce rigidity by accelerating the retarded elastic deformation. Either phenomenon may predominate depending upon the material, temperature, and cure time.

Measurements of apparent modulus over a range of cure times, at constant temperature and pressure, classify similar materials in roughly the order of their commercial molding speeds. However, different materials respond in different ways to changes in molding temperature. And, in order to obtain a complete picture, the effects of both cure time and temperature must be determined so as to characterize materials with regard to their curing behavior. Measurement of apparent modulus over a commercially useful range of both of these variables yields a practical estimate of their behavior in the molding operation.

Tests on a variety of phenolic and other thermosetting materials have served not only to characterize these materials, but also to illustrate the reasons for their behavior during the molding operation. Phenolic materials probably never approach complete cure under commercial molding conditions. This appears to be true for all other materials tested with the exception of a mineral-filled alkyd.

Discussion

Theory

The rigidity of a material can be conveniently measured by molding a specimen of simple geometry for example, a beam, subjecting it to a load, and observing its deformation. Depending upon the rheological properties of the material, the response to this loading will vary in both magnitude and nature.

An ideal viscoelastic material will exhibit a combination of three types of deformation when subjected to constant stress. These include:

1. Instantaneous elastic deformation which is proportional to stress. Upon removal of the stress, it is instantaneously and fully recoverable.
2. Retarded elastic deformation which is also proportional to stress but time-dependent. The extent to which this portion of the deformation is retarded is expressed by a certain retardation time. Recovery is complete but time-dependent.
3. Viscous flow, in which deformation continues at a constant rate, is proportional to stress. It is not recoverable.

The deformation and recovery of such a material may be represented by a mechanical model similar to that shown in Fig. 1.

Noncrosslinked high polymers at elevated temperatures exhibit a behavior that is more complex than the ideal situation just described. Studies of the actual viscoelastic behavior of such polymers indicate that the retarded elastic deformation is characterized by, not one, but a series of retardation times. Nonetheless, this observed actual behavior may be considered as similar to the ideal.

In contrast to the ideal and actual behavior of the noncrosslinked materials, ideal highly crosslinked high polymers differ in that they cannot exhibit true viscous flow unless primary valence bonds are broken. In other words, the stress at equilibrium deformation receives its support from the polymer network. Also, the absence of purely viscous flow simplifies the ideal deformation behavior shown in Fig. 1. Thus, on application of a stress, instantaneous elastic deformation occurs. This is followed by retarded elastic deformation which approaches an equilibrium value at a diminishing rate. The instantaneous elastic deformation is

recovered immediately upon removal of the load, and the retarded elastic deformation is also completely recovered, but at a diminishing rate.

The actual behavior of these highly crosslinked materials again is more complicated than the ideal in that total recovery from retarded elastic deformation may not be accomplished.

If flexural (deformation) tests were performed under nonequilibrium conditions, that is, chemical reactions leading to the formation of the polymers were progressing at an appreciable rate, the parameters would change while the tests were in progress. For this reason, the rigidity measurements of hot thermoset moldings that are still curing must necessarily be accomplished by a test of short duration. A test of this type, of course, does not completely define the retarded elastic behavior of the material. On the other hand, it has been found that an apparent modulus of elasticity, calculated on the basis of total deformation at some fixed time after application of the stress, is a meaningful and useful parameter.

Technique of Measurement

Equipment Requirements.—In order to measure the rigidity of a hot molded material, it was necessary to: (1) mold a specimen of suitable geometry under very closely controlled conditions of time, temperature, and pressure; (2) rapidly transfer the specimen, without cooling, to a testing chamber maintained at the same temperature as the mold; and (3) bend the specimen under a constant load, and record the resulting deflection as a function of time. Requirement No. 2 is of extreme importance because of the sensitivity of rigidity to the temperature of the specimen. Figure 2 vividly demonstrates the increase in rigidity resulting from cooling when a molded specimen is transferred from the hot mold to the flexure jig at room temperature.

The requirements tabulated above were met by designing and building: (1) a well-channeled, fully positive mold for molding rectangular specimens; (2) a heated testing chamber, integral with the mold, in which the specimen could be mounted as a beam; (3) a device for applying an adjustable load to the center of the specimen; and (4) a system for graphically recording the specimen deflection as a function of time.

To permit valid calculations of apparent modulus of elasticity by means of a

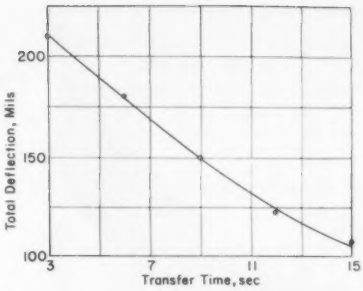

Fig. 2.—Variations in Deflection with Transfer Time of Hot Specimen Tested in Cold Jig under Constant Load.

simple beam formula,[3] it was necessary for the specimen to be of simple geometry, for flexural testing to be carried out with a span-depth ratio of at least 16,[4] and for only very small deflections to be employed. Adherence to the geometric and span-depth ratio requirements was accomplished by using a 1 by 5 by $\frac{1}{8}$-in. specimen and loading it on supports 4 in. apart. Concerning the deflection limitations, experiments indicated that deflection was approximately proportional to the effective load over an appreciable range of deflection.

The equipment, which is more fully described in the section "Description of Test Equipment," is shown in Figs. 7 and 8. Typical deflection-time and recovery-time curves are shown in Fig. 3.

Calculations.—The Young's modulus of a rectangular, weightless beam loaded at the center is given by the following equation:

$$E = \frac{Wl^3}{4Dwh^3} \quad \ldots\ldots(1)$$

where:

W = load at center of specimen,
l = span,
D = deflection at center,
w = width of specimen, and
h = thickness of specimen.

For this particular system, $l = 4$ in., and $w = 1$ in. Expressing W in grams, d in mils, and h in inches gives:

$$E = \frac{35.27W}{Dh^3} \text{ psi} \quad \ldots\ldots(2)$$

The weight of the specimen, uniformly distributed along its 5-in. length, introduces an additional bending moment that is equivalent to a concentrated load (at the center of a 4-in. span) of 0.35 multiplied by the weight of the specimen. Furthermore, the recorder mechanism requires 6 g to set it in motion. Hence, the value of W in Eq 2 is:

$$W = W_a + 0.35G - 6g \quad \ldots\ldots(3)$$

where:

W_a = applied load, g, and
G = specimen weight, g.

Substituting in Eq 2 gives:

$$E = 35.27\,\frac{(W_a + 0.35G - 6)}{Dh^3} \text{ psi} \quad \ldots\ldots(4)$$

Since deflection increases with time, the modulus of elasticity calculated from Eq 4 will decrease as D is measured at successively longer times after application of load. The value calculated from the deflection at any given time is an apparent modulus of elasticity (that is

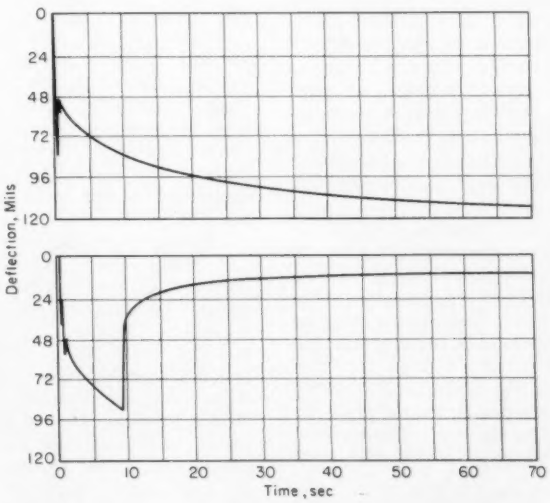

Fig. 3.—Typical Deflection-Time (Top) and Recovery-Time (Bottom) Graphs for 1 by 5 by $\frac{1}{8}$-in. Bars at Molding Temperature.

[3] Such a simple beam formula applies strictly only for infinitesimally small deflections and perfectly elastic materials of equal tensile and compressive moduli.

[4] ASTM Tentative Method of Test for Flexural Properties of Plastics (D 790 – 49 T), 1955 Book of ASTM Standards, Part 6, p. 165.

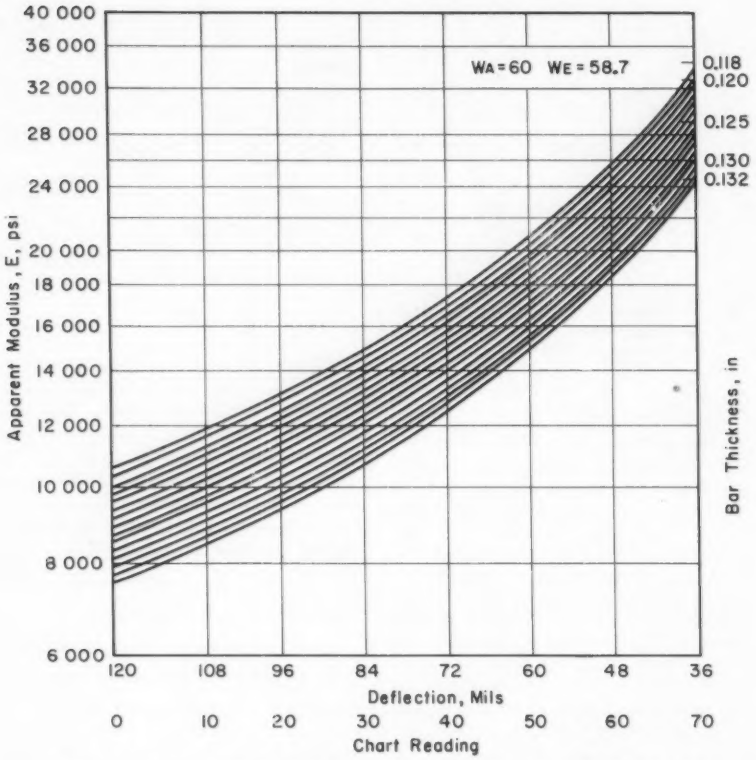

Fig. 4.—Apparent Modulus-Deflection Graph for Standard Applied Load.

the modulus of an ideal elastic body which would instantaneously deflect the same amount under the same conditions). Thus, Eq 4 may be rewritten:

$$E_t = \frac{35.27(W_a + 0.35G - 6)}{D_t h^3} \text{ psi} \quad \ldots (5)$$

where:

E_t = apparent modulus of elasticity corresponding to time t, and
D_t = deflection t sec after application of load.

It has been found both convenient and meaningful to use $t = 10$ sec for all measurements because (1) 10 sec is a short enough time interval during which relatively little additional chemical reaction can result in the specimen during the time of test, but long enough for good reproducibility of results, and (2) 10 sec is intermediate between the time that force is applied to a molded piece during ejection and during handling or cooling, subsequent to removal from the mold.

In practice, calculations of $E_t = 10$ by Eq 5 are eliminated by the use of graphs of *E versus D* for the several standardized values of W_a that are employed. They are calculated for ⅛-in. thick bars of 1.35 density (cellulosic-filled phenolic) for which the correction $0.35G - 6 = -1.3$[5].

Effect of Flash on Apparent Modulus.—A study of the various mechanical aspects that might affect apparent modulus measurements was pursued after the equipment was checked for proper operation.

Flash which forms along the edges of the molded test specimen produced a sufficient reinforcing effect so as to cause error in calculated values of apparent modulus with the more flexible specimens. This flash is stripped from the bottom surface during transfer of the specimen from the mold to the flexure jig. The flash on the upper surface is removed by a manually operated scraper.

Allowable Range of Deflection.—As indicated under "Equipment Requirements," the calculation of apparent modulus of elasticity is based on an equation which, when strictly applied, is valid only for infinitesimally small deflections. Experimental studies indicated, however, that as the load was varied, deflection was approximately proportional to the effective load over an appreciable range of deflection. This relationship is illustrated in Fig. 5. It is seen that the expected decrease in calculated apparent modulus did not occur until deflections exceeded 150 mils.

This made it possible to make measurements over a range of deflections and thereby avoid much trial-and-error in choice of load. Deflections were limited to the range of 36 to 120 (a 1:3.3 ratio), and standard loads, varying approximately in the ratio 1:2, were set up for routine testing.

Effect of Surface Cooling.—Initially, the molded bars were very slightly concave upwards when ejected from the mold. This was due to (1) slight cooling of the upper face during ejection and retraction of the force plug, and (2) continued heating of the lower face by contact with the bottom of the mold during this time.

In order to minimize this slight temperature difference, a pair of 250-w infrared lamps were mounted 12 in. from the mold cavity so as to radiate onto the specimen during ejection and keep the cover over the testing chamber hotter. This substantially eliminated the tendency of the molded bar to warp.

Effect of Specimen Weight.—The tendency of the molded specimen to bend under its own weight, while negligible with very rigid samples requiring large bending loads, was significant with more flexible samples. Thus, the correction discussed under "Calculations" was introduced. In addition, the force required to move the recorder mechanism was so adjusted (by a counterweight) that specimens having a specific gravity 1.7 or less could not deflect under their own weight prior to application of the load.

Effect of Application Rate of Bending Load.—The flexural testing device was so constructed that the loading foot just contacts the specimen prior to release of the weighted loading arm, which releases at a predetermined instant. The inertia of the arm, coupled with the very rapid initial deflection and subsequent rapid deceleration, results in momentary overloading of the specimen. Consequently, there is a slight hesitation or actual rebound of the arm and specimen. (See Fig. 3.) To determine whether this momentary overload was causing appreciable error, experiments were run in which the loading arm descended at a controlled rate. Under these conditions, the deflection 60 sec after application of the load was unchanged, and deflection 10 sec after loading was reduced by only 4 per cent. This reduction was probably due to the delay in application of the full load. So, no attempt was made to damp the deflection.

Effect of Specimen Thickness.—Since thickness of the section affects degree of cure by virtue of slower heat transfer,

[5] The weight of a 1 by 5 by 0.125-in. bar (hot) is 10.0 times the density of the cooled piece allowing 7.5 mils per in. shrinkage in all directions.

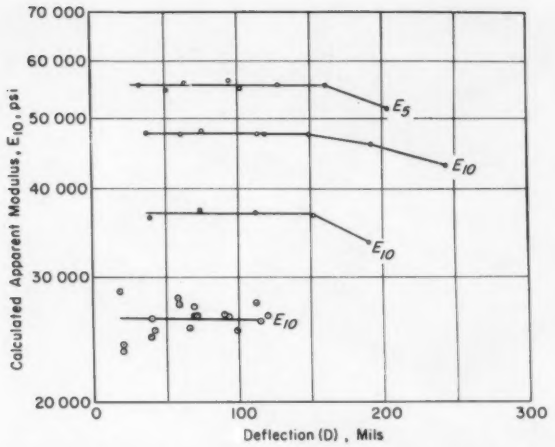

Fig. 5.—Effect of Deflection on Calculated Apparent Modulus of Elasticity.

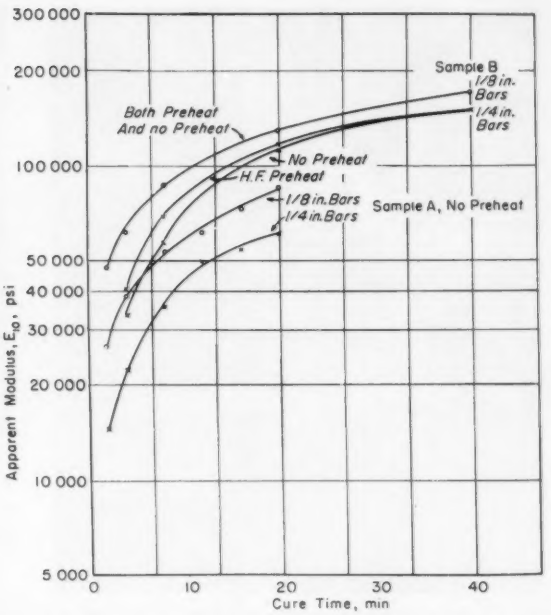

Fig. 6.—Effect of Specimen Thickness on Apparent Modulus at 365 F.

rigidity of hot molded pieces offered a possible means of studying the effect of thickness on cure rate in a quantitative manner.

Apparent moduli were determined for sample bars $\frac{1}{8}$ and $\frac{1}{4}$ in. thick at several cure times with and without high-frequency preheat. Bending loads were adjusted to give deflections that were inversely proportional to thickness so as to maintain approximately the same maximum stress in both sizes of the bar. The results are plotted in Fig. 6. Even after 40 min cure both with and without high-frequency preheat, the apparent modulus of elasticity of the thinner bars was still about 15 per cent greater than that of the thicker ones. When similar bars were cured for 16 hr to eliminate any possibility of difference in cure and cooled to room temperature, a standard flexural test showed the modulus of the thinner bars to be 16 per cent greater than that of the thicker ones.

The effect of thickness on modulus of elasticity of flexural specimens at room temperature is attributable to differences in span-depth ratio and other factors (30). It has been concluded that measurements of apparent modulus of elasticity of hot moldings are subject to the same limitations.

Effect of Breathe.—Breathing the mold (that is, briefly opening and closing it again before the material has hardened) permits the escape of gases, thereby reducing the minimum cure time at which a blister-free piece of most materials can be made and tested. Tests on samples of one-step and two-step phenolics over a range of pressures and cure times indicated that breathing the mold does not exert any appreciable effect on the rigidity, and hence, none on the curing reactions.

Description of Equipment and Testing Procedure

Description of Equipment.—The apparatus illustrated in Figs. 7 and 8 consists of a fully positive mold, a testing chamber integral with the mold, a flexure device, and a system for graphically recording results.

The mold, of hardened steel, consists of a chase and upper and lower force plugs. The lower force plug is raised to eject the piece in order to prevent distortion. So that pressure on the material may be well controlled, the design is fully positive. Steam channels have been provided in the top and bottom plungers, as well as in the chase, so that uniform temperatures may be maintained throughout.

The mold cavity is 1 in. wide and 5 in. long with accommodations for thickness variations up to $\frac{1}{2}$ in.

The testing chamber is a cavity machined into the mold block and is, therefore, maintained at mold temperature. The specimen is rapidly slid into it upon ejection by means of a manually operated transfer slide on top of the mold. Within the chamber are two knife-edge supports placed 4 in. apart on which the hot molded specimen rests.

The loading arm is fabricated of aluminum, mounted in ball bearings, and balanced by a counterweight. Its center of gravity is near the pivot point. This calibrated arm carries a sliding weight which exerts loads of 15, 30, 60, 105, or 150 g on the specimen. Additional weights to provide loads of 300, 600, and 1200 g may be hung from a knife-edge at the left end of the arm.

The recording system consists of an air-operated Taylor "Transet" Recorder and a Moore Products Co. "Motion Transmitter." The latter is actuated by a lever arm, one end of which is in contact with the lower face of the specimen. To minimize friction, the aluminum lever arm is mounted on jewel bearings. The "Motion Transmitter" linearly transforms the motion of its pilot rod into output air pressure in the range from 3 to 15 psi, which is transmitted to the recorder. A balancing speed of approximately 1 sec (full scale) is sufficiently fast for the measurements made. The recorder chart starts automatically as the loading arm is released.

The mold is mounted in a 15-ton Stokes automatic press (model 202A2). This press, with its controls modified for both operational and safety reasons, provides accurate and easy control of the rather complex cycle of operations and a minimum of test error from operator variables. Operation is semiautomatic.

Calibration of Equipment.—The recording mechanism was calibrated at both room and molding temperatures by means of a depth micrometer and simulated specimens prepared from rigid vinyl sheet and spring steel. Deviations from linearity were negligible.

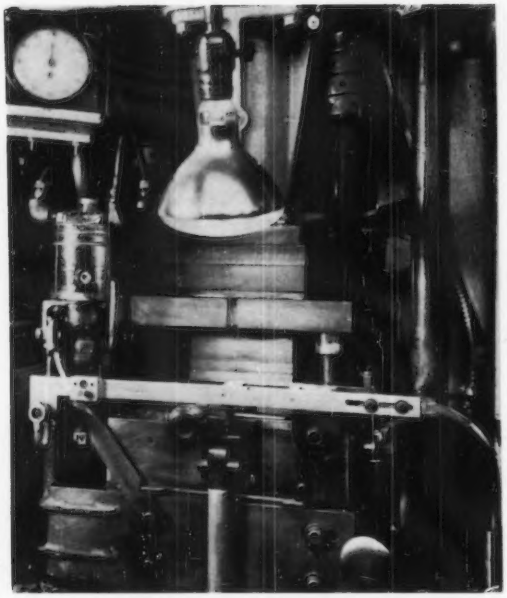

Fig. 7.—View of Semiautomatic Molding Press, Testing Chamber, and Flexural Apparatus.

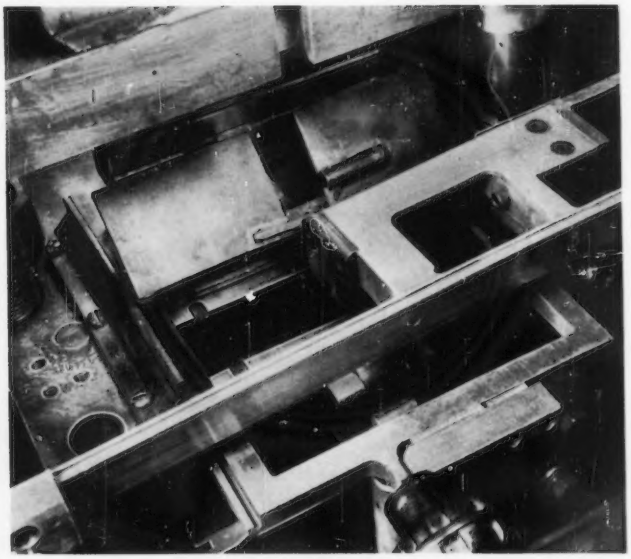

Fig. 8.—Close-up View of Testing Chamber with Transfer Slide Forward. Chamber Covers Are Raised to Show a Molded Test Bar During Flexural Test.

The loading arm was calibrated outside of the mold with the use of a sensitive balance.

The mold surface temperature was determined as a function of the heating steam pressure by use of a potentiometer and thermocouple while the mold was in cycle. The calibration is shown in Fig. 9.

Standard Operating Procedure.—Phenolic plastic bars are molded under the following standard conditions:

Pressure on piece, psi	2000
Thickness of piece (use charge weight based on specific gravity of material), in.	0.125 ± 0.007
Mold surface temperatures, deg Fahr.	305, 335, 365
Cure times (include 6 sec ejection, 3 sec transfer times), sec	50, 75, 120
Charge temperature	Room temp.

Materials other than phenolic, with appreciably different curing characteristics, are tested at 3 or 4 cures (ranging upward from their minimum blister-free time) chosen from the following: 20, 30, 50, 75, 120, 180, 270 sec. A temperature of 275 F may also be used if required. A "breathe" is normally employed to de-gas the specimen and, thereby, reduce the minimum time at which blister-free pieces may be obtained.

As the molded bar is ejected (by the lower force rising until it is flush with the top of the mold) the operator, in rapid succession, (*a*) scrapes excess flash from the top of the bar; (*b*) slides bar into the testing chamber by means of the transfer slide; and (*c*) exactly 3 sec after the transfer position is reached, applies the bending load.

Upon release of the load, the recorder

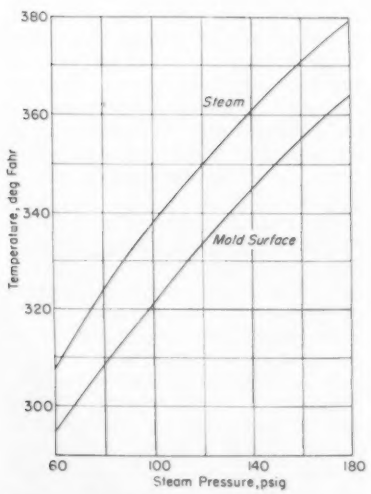

Fig. 9.—Mold Surface and Steam Temperatures Versus Steam Pressure.

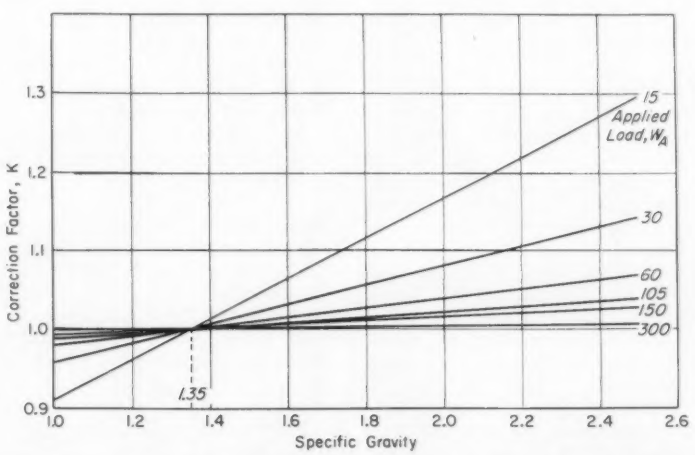

Fig. 10.—Correction to Apparent Modulus of Elasticity for Molded Specific Gravity of Material.

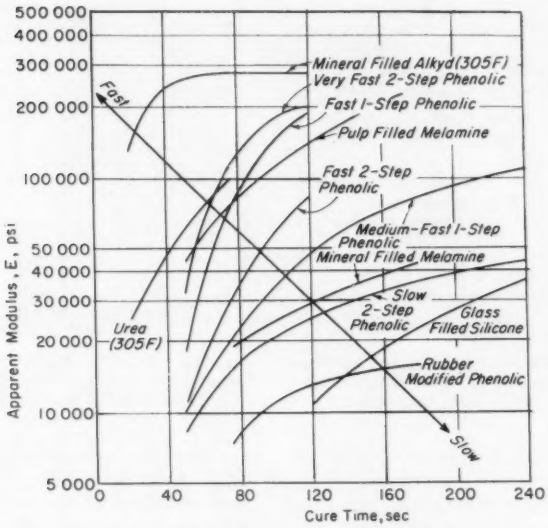

Fig. 11.—Relative Curing Rates of Several Materials (Temperature, 335 F except as noted).

chart is automatically started, and the deflection-time graph is drawn. The bending load has been previously selected from the available standard loads so as to yield a 10-sec deflection in the required range 36 to 120 mils. The thickness of the hot bar is measured to the nearest mil by a micrometer.

The apparent modulus of elasticity is then read from the graph of apparent modulus *versus* deflection (and corresponding chart reading at 10 sec) for the particular bending load and specimen thickness. A chart for the 60-g bending load is shown in Fig. 4.

The charts of apparent modulus *versus* deflection were calculated for materials having a molded specific gravity of 1.35, because this is a good approximation for general-purpose and medium-impact phenolics. When the molded specific gravity of the material under test departs appreciably from this value, the contribution of the specimen's weight to the bending moment will differ from the value used in the calculations.

A correction is readily made by multiplying the apparent modulus of elasticity, read from Fig. 4, by the appropriate value of K from Fig. 10.

Precision of Test.—The standard deviation of a single determination of apparent modulus of elasticity has been found to be 7.5 per cent over a wide range of materials and molding conditions. This is equivalent to a test error, at the 0.05 level, of ± 10 per cent for the average of two tests. The number of replications, usually two, may be adjusted to give the precision required. This error is small in relation to the more than 50 to 1 range of the test.

Applications of Apparent Modulus Measurements

Apparent modulus measurements have been used for some time in Bakelite Co. laboratories primarily for (1) material characterization and development and (2) studies of the influence of molding conditions on material behavior. Also, these quantitative data are being used to partially describe to the trade the curing properties of bakelite phenolic molding materials.

Comparison of Relative Cure Rates of Different Materials.—The curing reactions of a thermosetting material may be followed, at constant temperature and pressure, by apparent modulus measurements made at a number of cure times. Figure 11 illustrates the relative cure rates, as indicated by apparent modulus *versus* cure time curves at 335 F, of samples of various commercial molding materials. Two materials, the alkyd and urea, were run at 305 F, as these materials are normally molded at lower temperatures.

In general a rapid initial rise in apparent modulus (or rigidity) will be noticed, followed by a continuing increase as cure time is extended. This increase in rigidity is a consequence of the crosslinking reactions causing cure. It is of interest to note that the alkyd was the only material that appeared to be completely cured within the range of time employed. In the case of phenolic materials, the increase in rigidity continues for a very long period, indicating that complete cure is never attained, and probably never approached, under commercial molding conditions. Figure 6

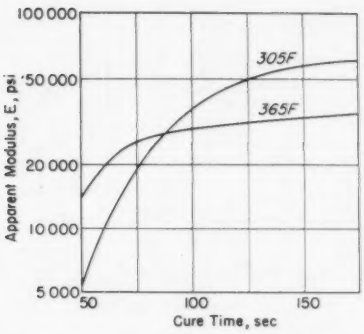

Fig. 12.—Effect of Cure Time on Rigidity of a General-Purpose Phenolic Material at Two Temperatures.

indicates appreciable increases in rigidity after 40 min cure at 365 F. In other tests, pieces cured for 16 hr at 325 F were found to be much more rigid than those cured for only 1 hr. A similar effect was noted at 347 F by Drumm, Dodge, and Nielsen (7).

Reference to Fig. 11 indicates that, by apparent modulus, these dissimilar materials are classified in the approximate order of their molding speed (as indicated by molding shop experience and other laboratory tests). The materials range from a mineral-filled alkyd (fastest) to a silicone and a rubber-modified phenolic (slowest). Correlations between rigidity and molding speed under conditions of normal usage is, of necessity, approximate. Factors such as piece and mold design, molding conditions, and other variables affect both the rigidity attained and that required for satisfactory operation. As a result, it is not possible to determine a minimum rigidity representing satisfactory performance in all molding operations, as a basis for exact comparisons of all molding materials.

Effect of Molding Conditions on Rigidity.—Time, temperature, and pressure are the variables which control the cure of a thermosetting material. The effect of time is always in the same direction. Longer cure time, unless decomposition or rearrangement occurs, results in greater rigidity up to the point at which essentially complete reaction is attained.

Variations in temperature affect rigidity by two mechanisms which are opposite in their effect:

1. Higher temperature results in faster reaction and, thus, in a more highly crosslinked, rigid, molecular structure at any fixed cure time.
2. For any given molecular structure, higher temperature results in lesser rigidity by virtue of reduction in the retardation times (see Theory).

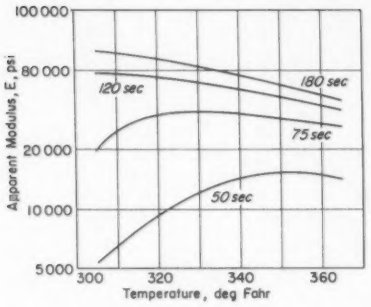

Fig. 13.—Effect of Temperature on Rigidity of a General-Purpose Phenolic Material at Several Cure Times.

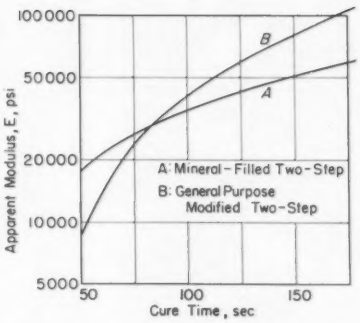

Fig. 14.—Relative Rigidities of Two Phenolic Materials at the Same Temperature (335 F) and Various Cure Times.

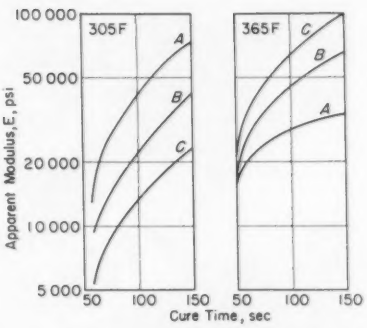

Fig. 15.—Relative Rigidities of Three General-Purpose Phenolic Materials at Different Temperatures.

Mechanism (1) predominates at low degrees of cure (short cure times and lower temperatures), and mechanism (2) stands out at higher degrees of cure. These effects are shown in Fig. 12. At the shortest cure time, pieces cured at 365 F were almost three times as rigid as those cured at 305 F due to faster chemical reaction at the higher temperature. As cure time was lengthened, the effect of temperature on retardation time became more of a factor. At the longest cure time, pieces cured at 365 F were only about half as rigid as those cured at 305 F. Thus, if cure time is not also taken into consideration, the resultant cross-over shown in Fig. 16 can give rise to conflicting reports on the effect of temperature.

This reversal in the effect of temperature as cure time is increased means that, for a given cure time, there must be some temperature at which rigidity is a maximum. This is shown by the data of Fig. 13, which is a plot of apparent modulus *versus* temperature obtained on the same material as was used for Fig. 12. It is significant to note that at the shortest cure time, the maximum occurs at a relatively high temperature. As cure time is increased, the point at which the maximum rigidity occurs shifts to a lower temperature value. In other words, as cure time is lengthened, the effect of increasing temperature becomes more one of promoting greater flexibility and, to a lesser extent, one of accelerating the reaction. The obvious practical importance of this effect in everyday molding problems should not be under-rated. However, it is important to note that (1) the effect of higher temperature is usually to promote greater rigidity, because cure times are kept as short as possible; and (2) the location of the maximum rigidity point depends upon a great many factors such as type of material, amount of preheat, thickness of section, and others. Therefore, the exact temperature at which maxima occur in Fig. 13 should not be taken as applying to all conditions of use. The principle, on the other hand, should apply under all conditions.

An increase in molding pressures, at constant temperature, generally appears to retard the curing reaction with a subsequent reduction in rigidity. Experimentation has indicated this to be true for one-step and two-step materials, for woodflour-filled and mineral-filled materials. A rise from 1000 psi to 6000 psi pressure has been found to cause reductions in apparent modulus that vary from within experimental error to 20 to 30 per cent. This does not mean that reducing molding pressure will always result in greater rigidity or faster cure. There are other controlling factors, including the heat generated by mechanical work done in flowing the material, which are likely to predominate. But it does suggest that, with flat pieces where very little flow is involved (for example, switch plates), cure may sometimes be accelerated by use of lower pressure.

Characterization of Materials by Apparent Modulus.—The curing characteristics of molding materials may be estimated for practical purposes by measurement of apparent modulus over a range of temperature and cure time. Response to these two variables must be determined in order to properly characterize materials.

The fallacy of basing estimates of relative cure speeds on comparison of rigidity at a single condition, or even over a range of cures at a single

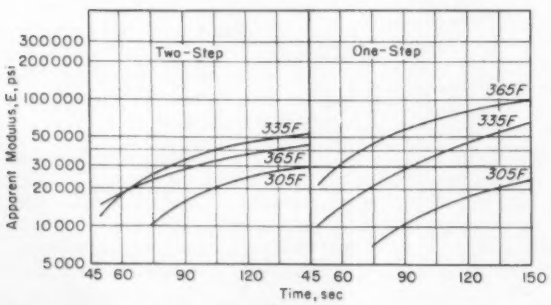

Fig. 16.—Apparent Moduli of Typical Woodflour-filled Phenolics.

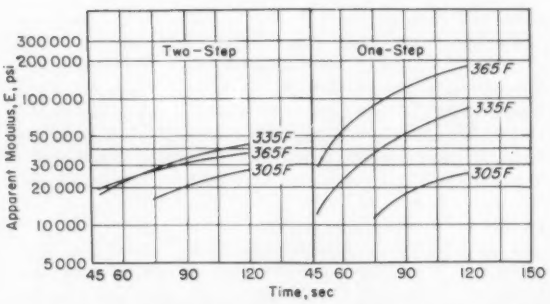

Fig. 17.—Apparent Moduli of Typical Flock-filled Phenolics.

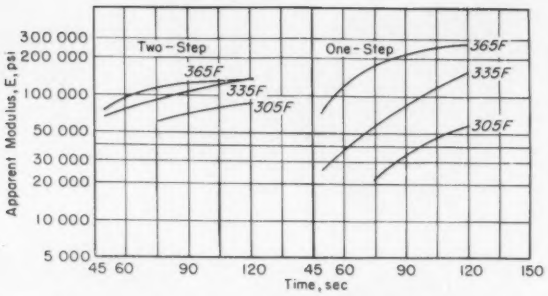

Fig. 18.—Apparent Moduli of Typical Rag-filled Phenolics.

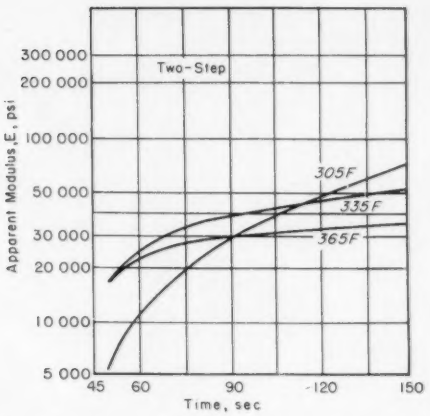

Fig. 19.—General-Purpose Phenolic with Good Low Temperature Molding Characteristics.

temperature, is illustrated by data plotted in Figs. 14 and 15.

Figure 14 shows the relative rigidities of two phenolic materials over a range of cure times at a single temperature (335 F). It is seen that at 50 sec cure, material A (an asbestos-filled two-step) is more than twice as rigid as material B (a general-purpose modified two-step). On the other hand, at the longest cure time of 180 sec, material A is only about half as rigid as material B. Figure 15 shows the relative rigidities of three general-purpose phenolic materials over a range of cure times at two different temperatures. Materials A and B are two-step, and material C is a one-step. The complete reversal in rigidities of the three materials resulting from changing temperature is evident.

In general, the relative molding speeds of different materials, in pieces whose minimum cure time is determined by elimination of blisters, are best estimated from relative rigidities at the shorter cure times. For example, at 335 F, the minimum blister-free time of mineral-filled material A in Fig. 14 is much lower than that of general-purpose material B. Rigidities at longer cure times are of practical concern for pieces in which the cure is extended by either rigidity requirement or the tendency of thicker sections to blister more.

A variety of phenolic and other thermosetting molding materials have been characterized as regards curing behavior by means of apparent modulus measurements made. The results are most meaningfully depicted by plots of apparent modulus *versus* cure time at each test temperature. Data for several materials are shown in Figs. 16 to 21. These have resulted in generalizations concerning material behavior as follows:

1. The acceleration in cure, and hence increase in rigidity, resulting from increasing temperature in the range 305 to 365 F, is much greater for one-step phenolics than for two-step phenolics. This is illustrated by Figs. 16, 17, and 18 which give data for typical two-step and one-step materials filled with woodflour, flock, and chopped cotton rags. The progressive increase in rigidity of the one-step phenolics with increasing temperature is evident even at the longest cure times employed. In contrast, the two-step phenolics show a progressive increase in rigidity with increasing temperature only at the shorter cures, and a cross-over between temperatures of 335 F and 365 F.

Practically, this means that cycle times can be reduced more effectively by increasing temperatures with one-step than with two-step phenolics. Other factors, such as molding latitude, impose restrictions, but it is noteworthy that phenolic closures (one of the largest outlets for general-purpose one-steps) are usually molded at very high mold temperatures.

2. Certain two-step, general-purpose phenolics are especially suited to low-temperature molding operations because they are faster curing and more rigid at low temperature than other general-purpose materials. Their rigidity does not increase as rapidly with increasing temperature and cure, as that of other two-steps. This is shown by Fig. 19, which represents a typical material of this type. It is seen that at the shortest cure time, increasing the temperature over 335 F does not further increase rigidity; and at the longest cure time, the lowest temperature gives the greater rigidity.

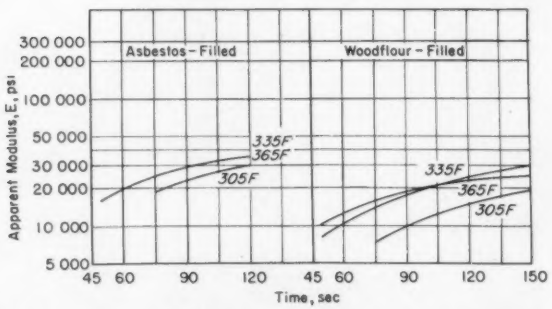

Fig. 20.—Comparative Apparent Moduli of an Asbestos and a Woodflour-filled Two-Step Phenolic of Similar Formulation.

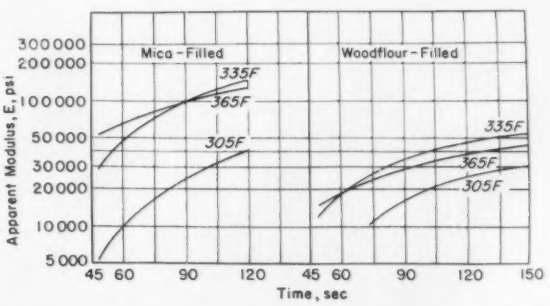

Fig. 21.—Comparative Apparent Moduli of a Mica and a Woodflour-filled Two-Step Phenolic of Similar Formulation.

3. Rag-filled materials, especially at short cure times, are more rigid than otherwise similar materials containing finely-divided fillers. This is due to the reinforcing effect of the filler. (Compare the rag-filled materials of Fig. 18 with the corresponding flock and woodflour-filled materials of Figs. 17 and 16.)

4. Mineral-filled materials are somewhat more rigid than woodflour-filled materials of otherwise similar formulation. The effect at short cure and low temperature is attributed to greater thermal conductivity, but at longer cures, it must be due to filler reinforcement similar to that noted at room temperature. (Mineral-filled phenolics are 1½ to 3 times as rigid as cellulosic-filled ones.) Two mineral-filled materials are compared with two general-purpose woodflour-filled materials in Figs. 20 and 21.

5. Silicones and rubber-modified phenolics are two classes of relatively slow-curing materials with very different characteristics. (See Fig. 22.) The silicones are slow-reacting (compared to, for example, phenolics) and therefore require a longer time to attain comparable rigidity at the same temperature. However, they become very rigid with longer cure and higher temperatures. The rubber-modified phenolics, on the other hand, are slow curing probably because the rubber content prevents the attainment of much rigidity. The result is that their rigidity rises very slowly with increased cure time and temperature.

Acknowledgment:

The author wishes to thank the Design Engineering Group of Bakelite Development Department for their assistance in designing the test apparatus; and Bakelite Co. for permission to publish this work.

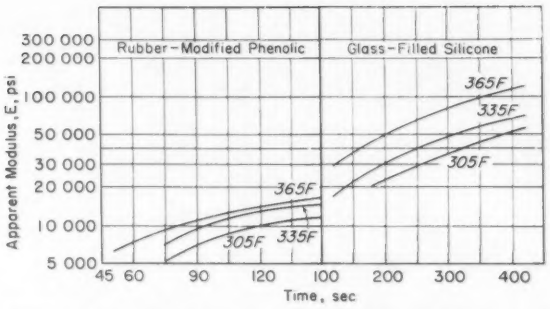

Fig. 22.—Apparent Moduli of a Typical Glass-filled Silicone and a Rubber-modified Phenolic.

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Accelerated Fatigue of Plastics

By LAWRENCE S. LAZAR

THERE are very few design engineers who are not aware of the tremendous structural and structural-insulating potentialities of plastics. The delaying factor in a mass substitution of a great number of plastics in many applications is the concern over the changes in strength of these plastics with time. This justified concern points to an enormous problem.

A material may fracture, sometimes catastrophically, under an alternating stress of only 25 per cent of its ultimate strength after having been subjected to these vibrational stresses for a long period of time. This strength-time phenomenon is fatigue. Fatigue, therefore, often determines the life of a plastic material in various applications.

The classical (Wohler) method of determining fatigue involves stressing a number of specimens at various constant alternating stresses to failure or to an arbitrarily chosen number of stress cycles (*S-N* diagram). Such data are usually highly scattered and the *S-N* plot involves the problem of treating samples which fracture together with those which endure the arbitrarily chosen number of cycles. Many times these phenomena occur at the same stress level. This means of interpreting fatigue requires rather extensive statistical analysis and is extremely time consuming. It is necessary, therefore, that a better short-time means of predicting fatigue be found.

In 1948, E. Marcel Prot (1)[1] reported a new accelerated technique for predicting fatigue limits. This method, the Prot progressive loading method, has been appraised by many investigators (2–6) to establish its reliability in predicting the fatigue limits of metals under rotating-beam fatigue conditions. The work described in this paper is an appraisal of the validity of this accelerated method using plastics under rotating and nonrotating fatigue conditions.

The Prot Progressive Loading Method appears to be a promising accelerated technique for determining the fatigue limits of plastics, which should be investigated further

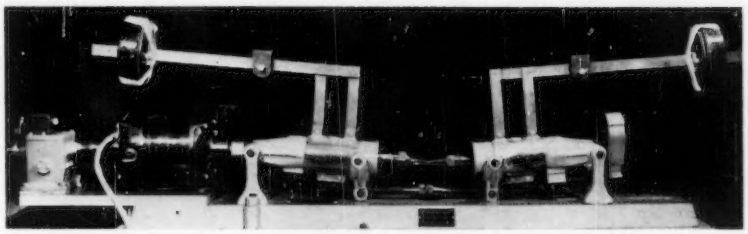

Fig. 1.—Moore Type Reversed-Pure Bending Fatigue Machine.

Apparatus and Specimens

Fatigue Machines

All of the rotating-beam fatigue data were obtained by rotating the samples under stress on a Moore type reversed-pure bending fatigue machine (see Fig. 1). Since the bearing housings were too heavy to permit using the machine to test plastics, counter balances were utilized to nullify any stress effects of these housings.

To conduct the Prot method, samples must be alternately stressed at various linear rates of increase of stress. In the work on polymethyl-methacrylate, this task was accomplished by adding lead shot (15 shot per g) into a container on the loading yoke. In work on polystyrene, progressive loading was done automatically using a spring scale loaded by a screw device driven by various speed gears as shown in Fig. 2. The problem of axial progressive loading was much more difficult. It was accomplished on a Sonntag SF-1U fatigue machine especially modified by the Sonntag Scientific Co. (see Fig. 3). A complete description of this instrument is contained in the Appendix.

Specimens

The work was limited to $\frac{1}{2}$-in. round specimens machined radially to provide a minimum thickness at the center. The samples were carefully polished to eliminate vertical scratches or machine marks. Emery cloth of grit Nos. 0 and 00, then 1573 A-B Buehler, Ltd. metcloths saturated with an aqueous suspension of 0.1 alumina, were used in this polishing operation. Any scratches on the surface were longitudinal in accord-

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NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] The boldface numbers in parentheses refer to the list of references appended to this paper.

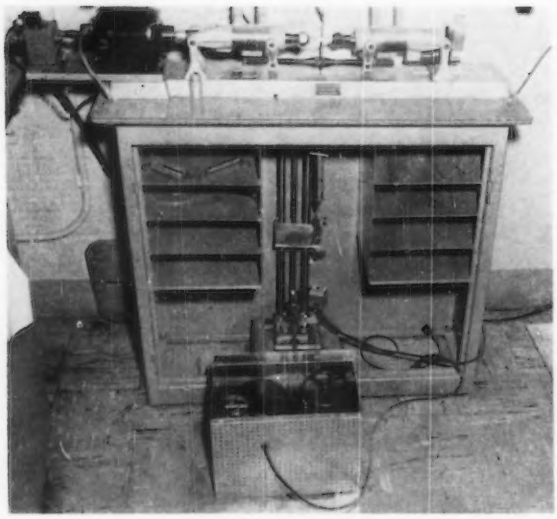

Fig. 2.—Moore Type Reversed Pure Bending Fatigue Machine Modified for Automatic Progressive Loading.

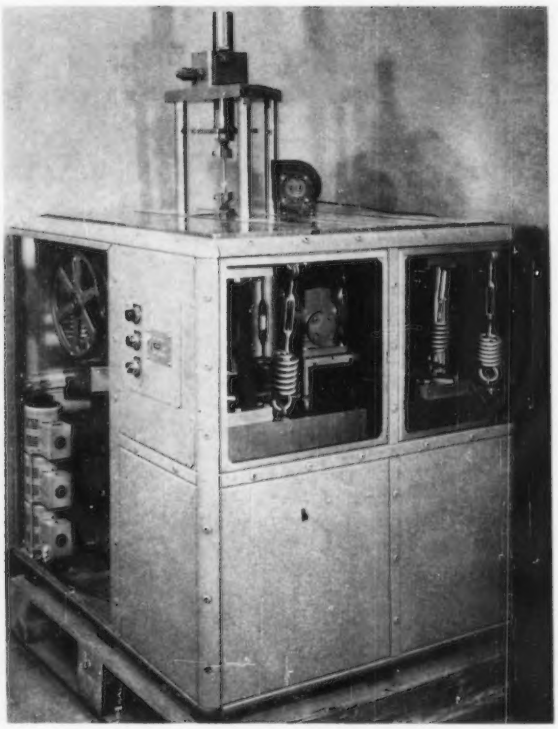

Fig. 3.—Sonntag SF-1U Fatigue Machine Especially Modified by the Sonntag Scientific Co.

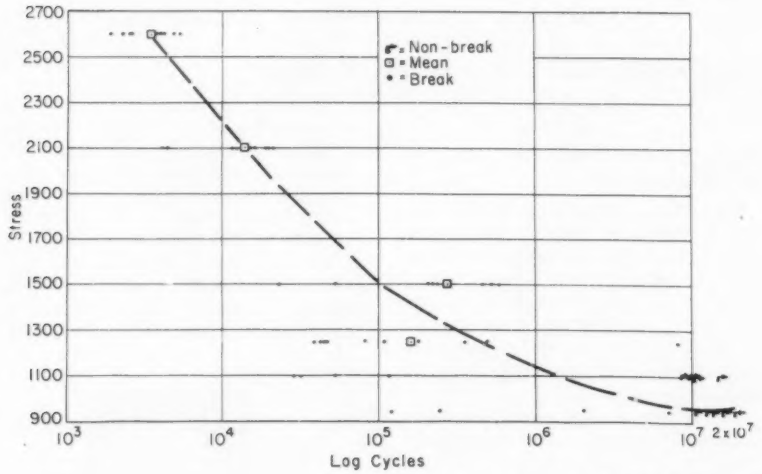

Fig. 4.—Wohler Fatigue of Polymethyl Methacrylate.

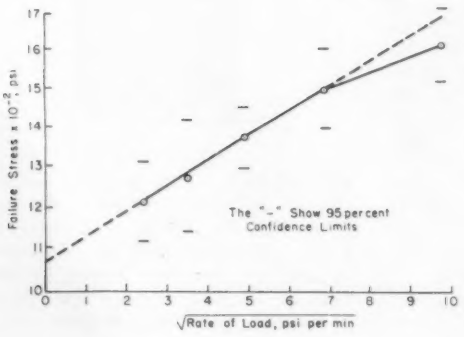

Fig. 5.—Prot Fatigue of Polymethyl Methacrylate.

ance with the ASTM Manual on Fatigue.[2]

Extruded polymethyl methacrylate and polystyrene were chosen as the first materials to be studied, since they are not only simple polymer systems but also offer the advantage of ease of machining and handling. They are thermoplastic materials which are noncrystalline[3] and after machining and polishing offer practically a scratch-free surface. Since they are transparent plastics, the observation of cracks as they form in the process of fatigue is facilitated.

Since highly crystalline nylon is used in so many applications where fatigue is the life-determining property, it was chosen as the third material to be studied in this search for an accelerated fatigue method. It is also the first small step taken in going from simple noncrystalline polymers to more complex systems. The nylon used was commercial rod stock.[4]

Experimental Findings

Polymethyl Methacrylate

In experimentation with acrylic, the usual Wohler fatigue test was conducted

[2] Fatigue Manual, Am. Soc. Testing Mats., *Special Technical Publication No. 91.*

[3] The noncrystallinity was determined by photoelastic means.

[4] DuPont Zytel No. 101.

first and the *S-N* curve shown in Fig. 4 was drawn. The Prot method was then tried at loading rates of 6, 12, 24, 48, and 96 psi per min. In this work some samples were started with no pre-load and some with 500 psi pre-load, but all points fell fairly close to the line as shown in Fig. 5. The curve was drawn through points which are averages of eight values. The 95 per cent confidence limits of these means are also shown. The extrapolation of this straight line indicates good agreement of the Prot endurance limit with the Wohler endurance limit.

Polystyrene

In experimentation with polystyrene, the following fatigue conditions were examined:

1. Alternating stress at a frequency of 1900 rpm (75 F and 50 per cent RH) on the "as received" material,
2. Alternating stress at 1900 rpm (75 F and 50 per cent RH), after annealing to remove all residual stress, and
3. Alternating stress at 360 rpm (75 F and 50 per cent RH), on the annealed polystyrene.

As in the case of the acrylic, the usual Wohler fatigue test was conducted and the *S-N* curves shown in Figs. 6, 7, and 8 were drawn. The rates of loading for the Prot method found to be most successful were 30, 15, 7.5, and 3.7 psi per min. When rates of loading faster than 48 psi per min with acrylic and 30 psi per min with polystyrene were used, the plot of stress to failure *versus* the square root of the rate of loading did not yield a straight line. The higher rates of loading yield fatigue breaks at stresses lower than might be expected by extrapolating the straight line obtained by plotting the breaks at slower rates of loading.

The Prot curves for all these conditions were drawn as straight lines, by the least square method, through points which are averages of five values. When these lines were extrapolated to zero rate of increase of load (by definition equal to the endurance limit), a close approximation of the endurance limit as obtained by the Wohler method, was effected (see Figs. 9, 10 and 11). In both the Prot and Wohler work, it seems that lowering the frequency raises the endurance limit of polystyrene. Residual stresses present in polystyrene however, only add to the scatter of the fatigue data. The residual stress work

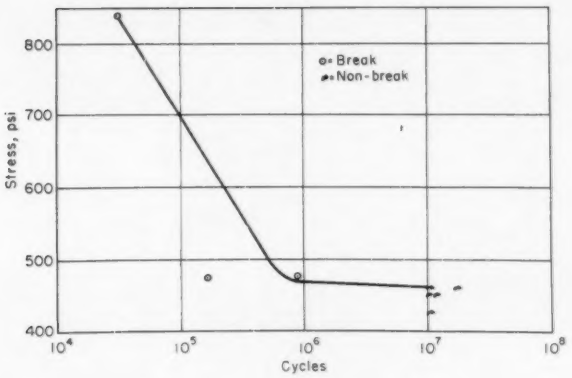

Fig. 6.—Wohler Fatigue of Unannealed Polystyrene at 1900 rpm.

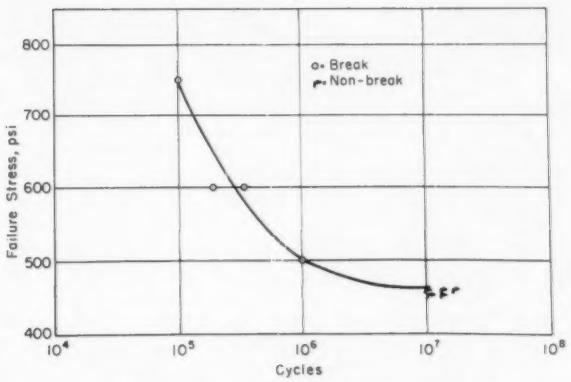

Fig. 7.—Wohler Fatigue of Annealed Polystyrene at 1900 rpm.

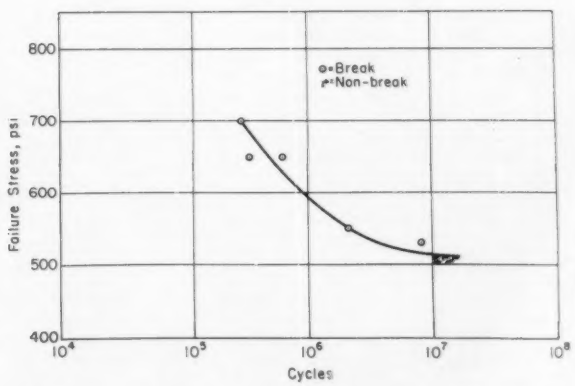

Fig. 8.—Wohler Fatigue of Annealed Polystyrene at 360 rpm.

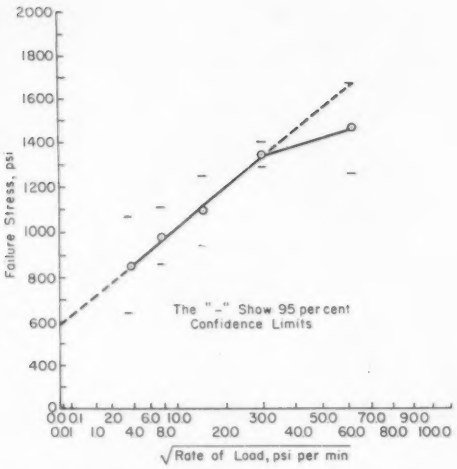

Fig. 9.—Prot Fatigue of Unannealed Polystyrene at 1900 rpm.

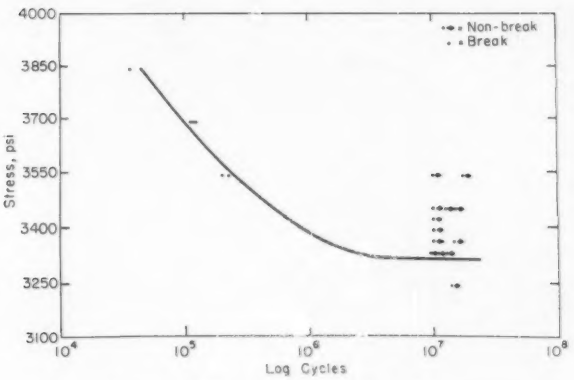

Fig. 12.—Wohler Fatigue of Gear Nylon.

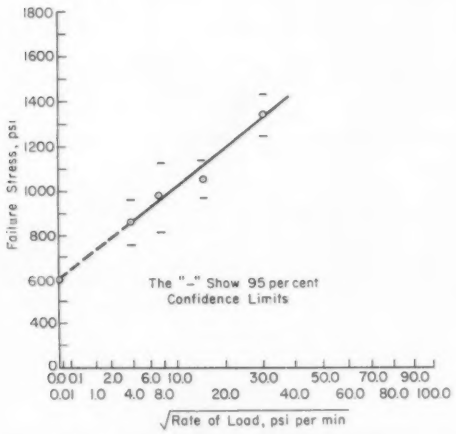

Fig. 10.—Prot Fatigue of Annealed Polystyrene at 1900 rpm.

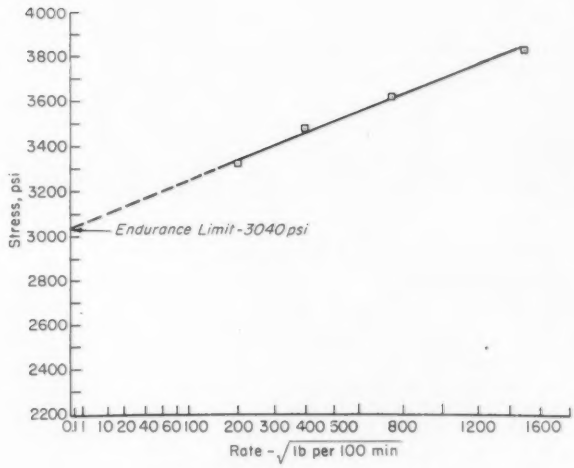

Fig. 13.—Prot Fatigue of Gear Nylon.

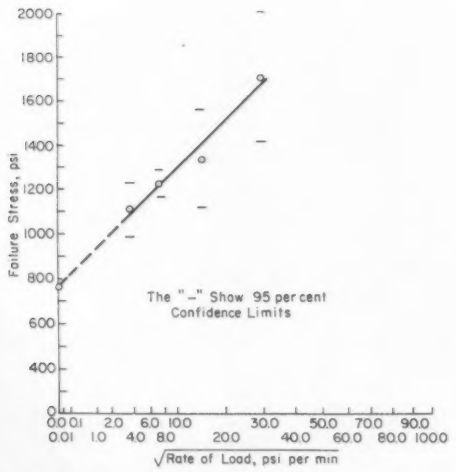

Fig. 11.—Prot Fatigue of Annealed Polystyrene at 360 rpm.

also indicates the excellent reproducibility of the Prot method.

Nylon

In experimentation with nylon, the axial fatigue properties of the material were investigated. The samples were alternately stressed in tension and compression through a mean stress of zero. As in previous work a Wohler fatigue study was conducted first (Fig. 12). The Prot experiments were conducted at rates of increase of alternate loading of 15, 7.5, 4.0, and 2.0 lb per min (Fig. 13). It is interesting to note that the Prot extrapolated endurance limit agrees within −7.8 per cent of the Wohler endurance limit. This is the only Prot endurance limit herein reported which is lower than a Wohler endurance limit.

Conclusions

In this preliminary investigation of relatively simple polymer systems under various fatigue conditions, the Prot method yields a good approximation of the endurance limit as obtained in conventional fatigue testing (see Table I). The work has shown that, as well as providing a good short-time estimate of the endurance limit under various conditions (a time saving of approximately 90 per cent), the Prot method eliminates the problem of treating data for samples which continue running beyond some arbitrary number of cycles in an ordinary fatigue test. The method also greatly reduces scatter, which becomes large near the endurance limit in an ordinary fatigue test. Further study of the Prot method of accelerated fatigue testing seems warranted.

TABLE I.—COMPARISON OF FINDINGS

Material	Specimen History	Testing Frequency, rpm	Type of Fatigue	Wohler Endurance Limit, psi	Prot Endurance Limit, psi
Acrylic.....	As received	1789	Rotating pure-bending	900	1050
Polystyrene..	As received	1900	Rotating pure-bending	460	600
Polystyrene..	Annealed	1900	Rotating pure-bending	460	600
Polystyrene..	Annealed	360	Rotating pure-bending	510	710
Nylon.....	As received	1800	Axial reversed tension-compression	3300	3010

APPENDIX

In the application of the Prot method, a low stress is placed upon the sample initially, and this stress is steadily increased during the test until failure occurs. While the applied stress is below the endurance limit of the material, no fatigue damage will occur. Fatigue will take place only when the applied stress equals or exceeds the endurance limit, S_e.

If S_e were known initially, progressive loading could be started at S_e and zero time (see Fig. 14). The coordinates of failure stress and failure time would describe a curve of hyperbolic form, asymptotic to S_e and would satisfy the equations:

$$(S - S_e) = at \quad \ldots\ldots\ldots (1)$$

$$(S - S_e)t = K \quad \ldots\ldots\ldots (2)$$

where:

S = failure stress,
a = rate of loading,
t = failure time,
S_e = endurance limit stress, and
K = constant.

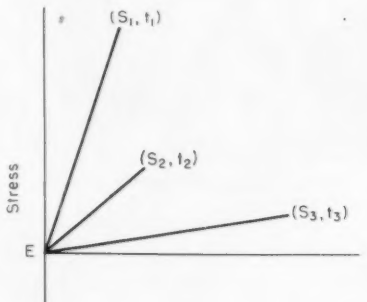

Fig. 14.—Postulated Hyperbolic Curve when Progressive Loading Started from S_e.

Because S_e is not known initially, loading is actually started at some stress below S_e, S_o, and at zero time (see Fig. 15). In this case, failure stress and failure time coordinates do not describe a single hyperbolic curve.

To get a hyperbolic curve in this second case, it is necessary to translate the intercepts t_{S_e} to zero time. Equations 1 and 2 would then become:

$$(S - S_e) = a(t - t_{S_e}) \quad \ldots\ldots (3)$$

$$(S - S_e)(t - t_{S_e}) = K \quad \ldots\ldots (4)$$

where t_{S_e} = time at which stress equals S_e.

When $(t - t_{S_e})$ is eliminated between Eqs. 3 and 4, then

$$(S - S_e)^2 = Ka \quad \ldots\ldots\ldots (5)$$

Because Eq 5 is independent of t, then t_{S_e} need not be known, and the Prot technique can be applied without prior knowledge of S_e. It is also evident from Eq 5 that a plot of failure stress *versus* the square root of the rate of increase of load should yield a straight line which intersects the stress ordinate at S_e.

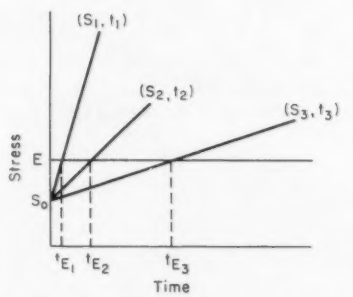

Fig. 15.—Postulated Curve when Loading Started below S_e.

Principle of Operation of Oscillator

The oscillator shown in Fig. 16 utilizes the centrifugal force of three unbalanced masses, called eccentrics, to generate a sinusoidal alternating force. The alternating force is steplessly adjustable from zero to a maximum of ±1000 lb.

The inner shaft, *1*, supported by ball bearings, carries two fixed unbalanced weights called fixed eccentrics, *2*. A cylindrical cam, *3*, mounted on the inner shaft, carries the third unbalanced weight, called adjustable eccentric, *4*.

The inner shaft, *1*, is driven by a synchronous motor at 18 rpm. A pin, *5*, that can be displaced axially, transmits the rotation from the inner shaft, *1*, to the cam, *3*.

The fixed and adjustable eccentrics have an equal and opposite unbalance when the phase angle is 180 deg. When the phase angle between the eccentrics is changed, a rotating force is produced when the inner shaft is rotated. The horizontal component of the rotating force is absorbed by four flexplates, which guide the oscillator in a vertical plane. The fixed ends of these flexplates are fastened to the heavy frame of the machine. Thus, an alternating sinusoidal force in the vertical plane is produced by the oscillator.

The magnitude of the resulting force is a function of the phase angle between fixed and adjustable eccentrics. The phase adjusting mechanism consists of a pin, *5*, a sleeve (hidden from view), and a screw, *6*. The pin, *5*, is engaged in a straight axial slot in the inner shaft, *1*, and in a "helically shaped" groove in the cylindrical cam, *3*. By moving the pin axially, the adjustable eccentric can be rotated relative to the fixed eccentrics.

The axial position of the pin determines the phase angle between the eccentrics and, hence, the force output. The pin is closely positioned by means of an adjusting screw, *6*, threaded into the housing. Ball bearings mounted on the adjusting screw allow shifting the pin axially while the eccentric assembly is rotating. The adjusting screw is linked by torsionally stiff membrane-type couplings through an

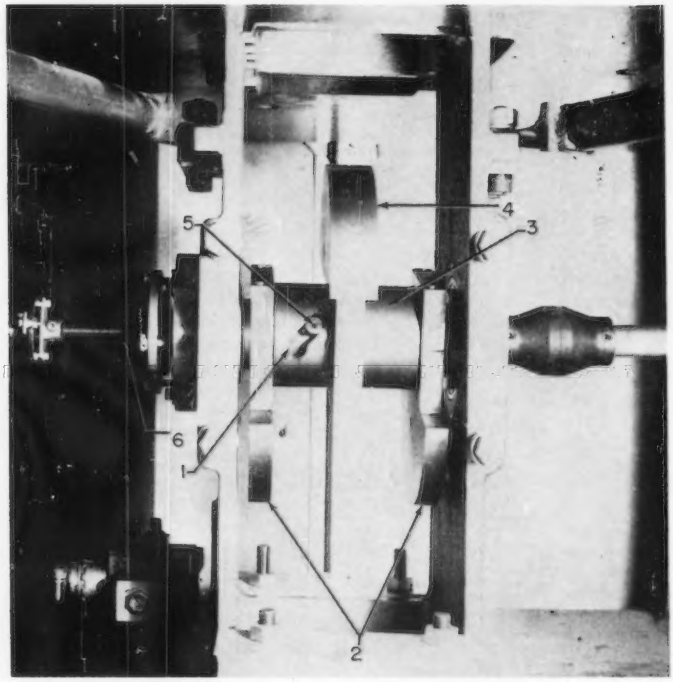

Fig. 16.—Progressive Loading Oscillator.

intermediate shaft with the force-setting knob.

The force-setting mechanism consists of threaded shaft actuated by an axially fixed knob through a key and keyway. Turning the force-setting knob rotates the threaded shaft, which actuates the phase-shifting mechanism. Axial backlash and fretting is eliminated by preloading the threaded shafts and by means of conical disk washers.

Rotation of the force-setting knob is transmitted through bevel gears to a small counter. A linear relationship knob and the dynamic force output of the oscillator. The linearity was achieved by means of a special cylindrical cam. The counter is calibrated to read the force output directly in pounds.

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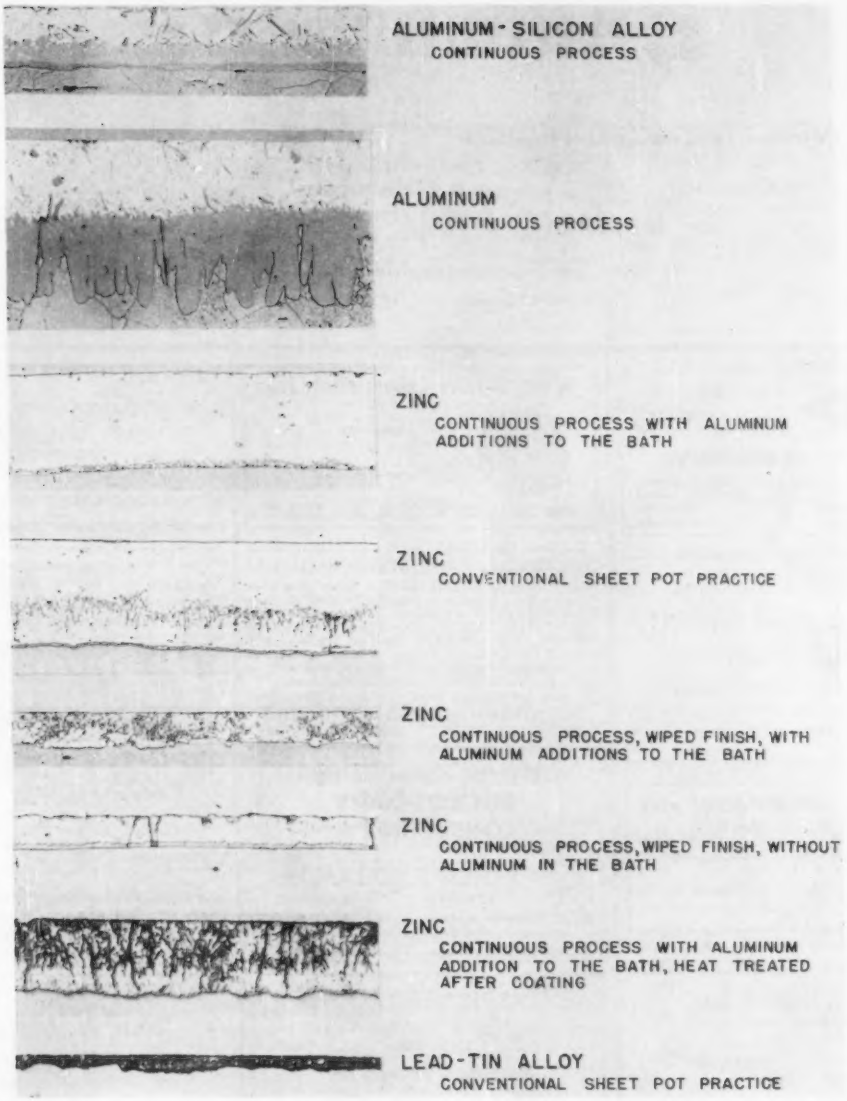

Hot Dipped Metallic Coatings on Steel Sheets × 1000 (Reduced for publication)

First Prize, Photomicrographs, Black and White, Tenth ASTM Photographic Exhibit. Esther C. Johnson, Research Laboratories, Armco Steel Corp., Middletown, Ohio.

Aluminum silicon alloy—continuous process
Aluminum—continuous process
Zinc—continuous process with aluminum additions to the bath
Zinc—conventional sheet pot practice
Zinc—continuous process, wiped finish, with aluminum addition to the bath
Zinc—continuous process, wiped finish, without aluminum in the bath
Zinc—continuous process with aluminum addition to the bath, heat treated after coating
Lead tin alloy—conventional sheet pot practice

All samples are hand polished on emery paper with wax dissolved in kerosine used as a lubricant on the last two papers. This is followed by wet polishing on silk-covered wheels using levigated alumina suspended in a soap solution, followed by alpha alumina in soap solution, and gamma alumina in soap solution. Polishing on the silk wheel is followed with polishing on billiard cloth using the alpha solution and then on microcloth with the gamma solution. Zinc samples are rinsed with amyl alcohol rather than water.

All photomicrographs are × 1000 taken on a Zeiss metallograph using Homal VI and 60× 0.95 N.A. (air) objective. Zinc-coated samples were etched with Timofeefs' etch while the aluminum coated samples were etched with 3 per cent Nital. The lead-tin alloy is unetched.

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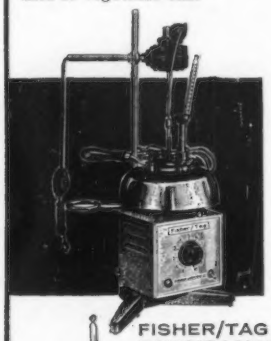

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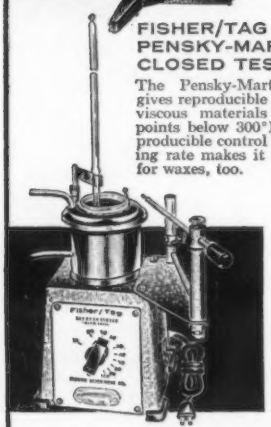

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CIRCLE 429 ON READER SERVICE CARD
PAGE 105

PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

NOTE—*These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as a key letter. It is believed that this arrangement will facilitate reference to the news about members.*

The following were among thirty new members recently appointed on advisory boards of the publications of the American Chemical Society: **Raymond W. McNamee,** manager of Union Carbide and Carbon Research Administration, and **Thomas H. Vaughan,** vice-president and president-elect, Industrial Research Institute—*Chemical and Engineering News;* **E. E. McSweeney,** manager, department of chemistry, Battelle Memorial Institute —*Industrial and Engineering Chemistry;* **James I. Hoffman,** head of the Metallurgy Division, National Bureau of Standards, and **Raymond G. Russell,** emission spectroscopist, Gulf Research & Development Co.—*Analytical Chemistry;* **Joseph W. E. Harrison,** director, LaWall and Harrisson Research Laboratories, and **Allen B. Lemmon,** chief of the division of plant industry, California Department of Agriculture—*Agricultural and Food Chemistry.*

Marvin Antelman, formerly with Marantes Laboratories, Ventor, N. J., is now research chemist, Inorganic Chemicals Div., Research Dept., Monsanto Chemical Co., Boston, Mass.

Hugh F. Beeghly Chairman of the ASTM Pittsburgh District, has been named research associate at Jones & Laughlin Steel Corp., Pittsburgh, Pa. Mr. Beeghly is active also in the work of Committee E-3 on Chemical Analysis of Metals, heading the division concerned with general analytical methods.

Maurice H. Bigelow is now technical director, Barrett Division, Allied Chemical & Dye Corp., New York City. Until recently he was director of the Research and Development Dept. of the Division.

Paul Owen Blackmore, sales promotion manager, Finishes Div., Interchemical Corp., Newark, N. J., was the 1956 recipient of the George B. Heckel Paint Industry Magazine Award for Technology and Production. Although Mr. Blackmore has contributed many important developments to paints and protective coatings, he is best known for his work in the specialized fields—industrial finishes, infrared reflection of coatings, corrosion protection, and labor.

Orlan W. Boston, who retired last July at his own request as professor of mechanical engineering and of production engineering, and chairman of the Department of Production Engineering, University of Michigan, has been made professor emeritus of mechanical engineering and production engineering. Professor Boston has been serving for a number of years on Technical Committee K on Cutting Fluids, of Committee D-2 on Petroleum Products and Lubricants, heading the subgroup concerned with definitions, functions, types, and designations of cutting fluids.

Paul M. Brister has been appointed manager, engineering design section, Manufacturing Engineering Dept., The Babcock & Wilcox Co., Barberton, Ohio. He was formerly in the New York office as Engineering Department coordinator.

Joseph Brobston recently retired as chairman of the Board of Directors, Hercules Cement Corp., Philadelphia, Pa. Mr. Brobston was very active for many years in Committee C-1 on Cement, and in recognition of valued contributions was elected to honorary membership in that group in 1949.

Wallace R. Brode, associate director of the National Bureau of Standards, Washington, D. C., is president-elect of the American Association for the Advancement of Science; he will be president during 1958. The 13th chemist to head the AAAS since its founding in 1848, Dr. Brode is responsible at the Bureau for work in the chemical, metallurgical, mineral products, and optical areas, also has general direction of educational, publications, and foreign relations. ASTM follows the work of AAAS, Executive Secretary **R. J. Painter** being a Fellow and a member of the Council, interested particularly in Section M on Engineering.

Russel B. Caples, president and director of Anaconda Aluminum Co., New York City, was honored by the American Institute of Mining, Metallurgical and Petroleum Engineers, with the James Douglas Medal "for distinguished achievements in extractive metallurgy, particularly in the electrowinning of zinc, and for outstanding success in stimulating the professional careers of many metallurgists."

Ralph W. Chadbourn retired December 31 as head of the testing and standards section, Boston Edison Co , Boston, Mass. He had represented his company in the Society since 1929, serving on several of the technical committees, rendering valued aid especially in Committee D-9 on Electrical Insulating Materials where he was a member of the Advisory and many other subgroups, heading for some time those concerned with insulating fabrics and insulating papers. He was a member of the New England District Council for ten

(*Continued on page 80*)

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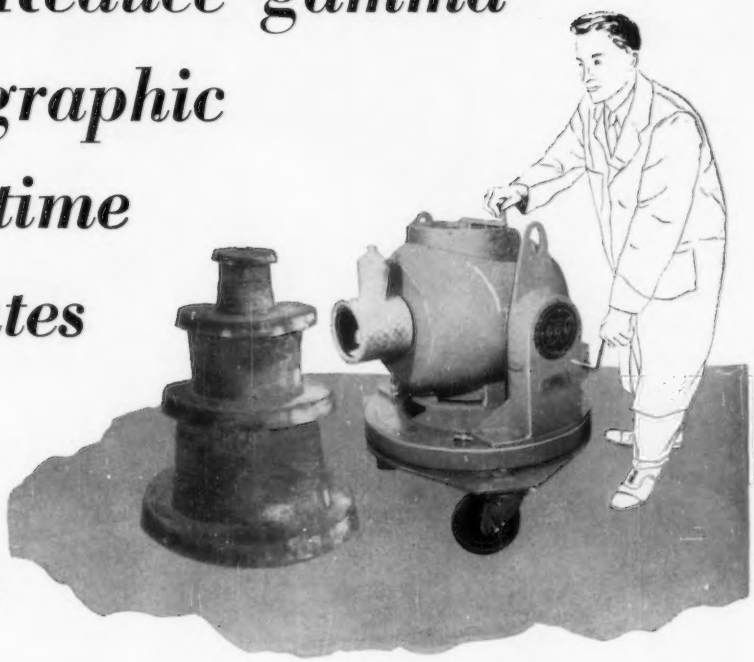

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FOR FURTHER INFORMATION CIRCLE 430 ON READER SERVICE CARD PAGE 105

Personals

(*Continued from page 78*)

years, serving as secretary 1952–56. Mr. Chadbourn resides at 394 Pleasant St., Melrose, Mass.

Marvin B. Chittick, of the American Mineral Spirits Co., Murray Hill, N. J., was honored at the 1956 Annual Meeting of the National Lubricating Grease Institute as recipient of the NLGI award, an engraved silver tray. He was cited as a former Institute president who had "contributed mightily to Institute successes . . .developing the lubricating grease classification now used internationally."

John L. Christie is retiring as manager, Metallurgical Dept., Handy & Harman, Bridgeport, Conn. He has represented his company for many years on a number of the ASTM non-ferrous committees, also served as official representative of the company membership in the Society. Mr. Christie plans to continue to make his home in Fairfield, Conn. Mr. Christie has been associated with the society for at least 35 years. He recalls being in Committee B-2 when Messrs. Campbell and Thum were officers, and in Committee B-3 when T. S. Fuller was chairman and Sam Tour, secretary. He headed Subcommittee V of B-3 on Accelerated Electrolytic Test for some time. In his earlier years he was associated with the Bridgeport Brass Co.

Kenneth M. Clark is now president, K. M. Clark Engineering Co., Minneapolis, Minn.

D. S. Colburn recently retired as vice-president of Marquette Cement Manufacturing Co., Chicago, Ill. Mr. Colburn represented his company for many years in the Society and on Committee C-1 on Cement.

R. B. Corbett, until recently director of research for the Heppenstall Co., Pittsburgh, has been appointed director of metallurgy, Consumable Electrode Vacuum Melting Dept., Midvale-Heppenstall Co., Philadelphia, Pa.

Charles F. Cromwell, Jr., formerly agricultural engineer, U. S. Dept. of Agriculture, Soil Conservation Service, Imperial, Calif., is now assistant professor of agricultural engineering, Department of Agricultural Engineering, University of Missouri, Columbia, Mo.

Herbert W. Eckweiler has retired as assistant chief chemist, U. S. Bureau of Customs Laboratory, New York City. Mr. Eckweiler has served on Section B on Chemical Analysis, Research Division XII on Graphite Tests of Committee D-2 on Petroleum Products and Lubricants.

Herbert O. Fleisher has been appointed chief of the Division of Timber Processing of U. S. Forest Products Laboratory, Madison, Wis., taking over the field of work formerly covered by **T. R. Truax,** who retired Dec. 31, 1956.

Alfred M. Freudenthal, professor of Civil Engineering at Columbia University, New York City, was awarded the 1956 Medal of the Swedish Aeronautical Society. The award was conferred after Dr. Freudenthal read a paper on "Thermal Stresses in Aircraft" before members of the Swedish Society of Engineers last fall. **K. O. Lundberg,** president of the engineering group and director of the Aeronautical Research Institute of Sweden, made the presentation.

Paul E. Gagnon, formerly director of the Chemistry Department, Laval University, Quebec, Canada, is now dean of the Graduate School.

H. Mills Garner recently retired as vice-president, Magnesium Elektron, Inc., New York City.

(*Continued on page 82*)

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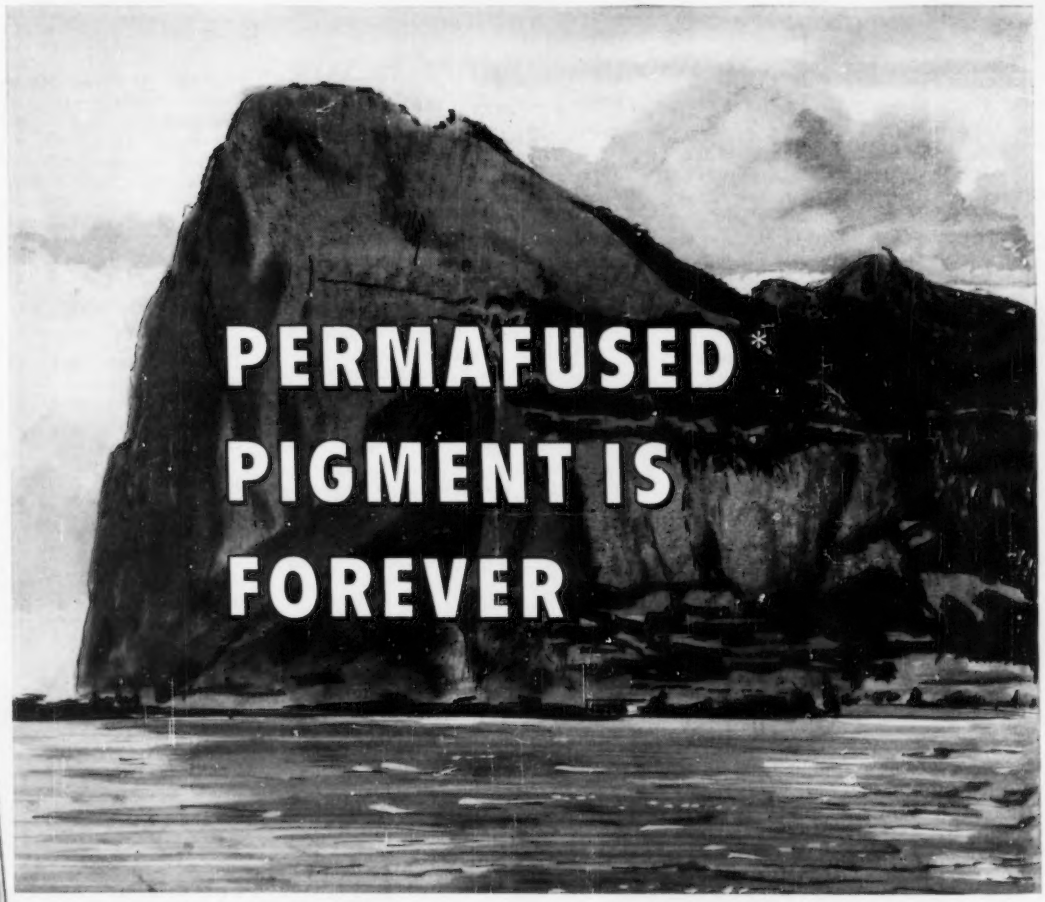


WE'D carve this phrase into the towering cliffs of the Rock of Gibraltar if we listened to our engineers—and if the British would let us—because that's how proud our engineers are of new PERMAFUSED Pigment. "It's Legibility That Lasts," they tell us. "The markings on our new etched-stem, mercury-filled laboratory thermometers *will last as long as the instruments themselves.*"

"That permanently-permanent PERMAFUSED Pigment is fused *directly into the* glass," they add. "It becomes a part of it!"

Here's what their pride, their pigment and their product mean to you.

- You can read these thermometers as long as there's light!
- No solution you test will affect the markings—not even organic solvents—except acids that destory the glass itself!
- There's no chance of contaminating test solutions with dissolved pigments!

Every Taylor etched thermometer, ASTM, Plain, Armored or Pocket-Type is precision-built and expertly annealed for minimum breakage. The permanent accuracy of the Taylor laboratory thermometer you choose is assured by skilled workmanship and expert ageing before pointing. Taylor thermometers are available with all scales recognized by the Bureau of Standards. Special designs are made to order for specific scientific, research and production purposes.

PERMAFUSED Pigments mean "Legibility That Lasts." For further information on what this can mean to your laboratory, call your Taylor supplier or write for **Catalog LH.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada.

Taylor Instruments MEAN ACCURACY FIRST

FOR FURTHER INFORMATION CIRCLE 432 ON READER SERVICE CARD PAGE 105

Personals

(*Continued from page 80*)

William H. Graves, previously vice-president and director of engineering, Studebaker-Packard Corp., has been appointed professor of automotive engineering in the Department of Mechanical Engineering, University of Michigan, Ann Arbor, Mich.

George Russell Harrison, dean of science at Massachusetts Institute of Technology, Cambridge, will receive the first Pittsburgh Spectroscopy Award, established by the Spectroscopy Society of Pittsburgh to honor those making distinguished contributions to this field of science. Presentation will be made at the Pittsburgh conference March 6.

Raymond H. Hobard, formerly manager, The Haller Test Labs., Inc., New Haven, Conn., is now materials engineer, Bridgeport Concrete and Asphalt Co., Bridgeport, Conn.

H. O. Hill recently retired as assistant chief engineer, Fabricated Steel Construction, Bethlehem Steel Co., Inc., Bethlehem, Pa. Mr. Hill has been active in the work of Committees A-1 on Steel, and A-5 on Corrosion of Iron and Steel for the past 25 years.

William F. Little, president of Electrical Testing Laboratories, Inc., New York City, retired at the end of 1956 after nearly 50 years of service. Mr. Little has been active through the years on several of the technical groups, including Committees C-14 on Glass and D-20 on Plastics.

Berndt K. Lyckberg has been appointed general manager of the new high density polyethylene plant of W. R. Grace & Co.'s Polymer Chemicals Division in Baton Rouge, La. For the past five years Mr. Lyckberg had been manager of the chemical laboratories of Firestone Plastics Co., Pottstown, Pa.

Ralph G. May, formerly production engineer, The Kawneer Co., Cynthiana, Ky., is now associated with International Business Machines Corp., Lexington, Ky.

Robert K. Multer, until recently with Marbon Chemical Div., Borg-Warner Corp., Garry, Ind., is now with Architectural Tiling Co., Inc., of Keyport, N. J., working out of Chesterton, Ind.

Don O. Noel has been named assistant to the president at Metals Disintegrating Co., Elizabeth, N. J.

Albert W. Ondis has been appointed eastern regional manager for Brush Electronics Co., division of Clevite Corp., Cleveland. His headquarters will be at the standard products office at Arlington, Va. Until recently he had been manager of the Brush Southeastern office, Greenville, S. C.

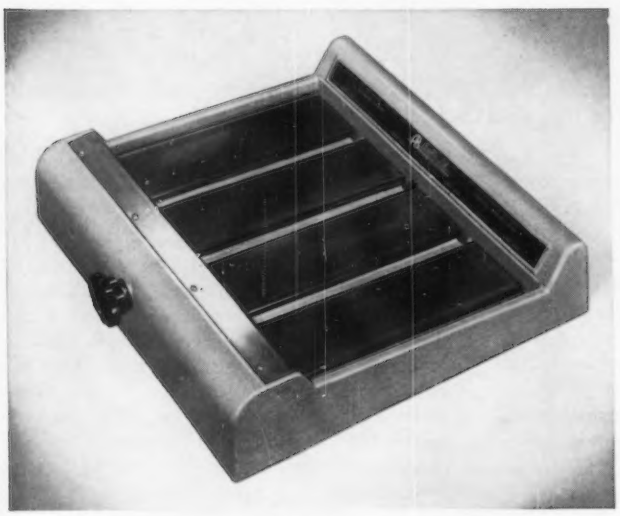
C. Dean Ramsden has been appointed vice-president and general manager of Pacific Coast Engineering Co., Alameda, Calif.

C. R. Richards, formerly chief metallurgist, was made vice-president—metallurgy and research, Adirondack Foundaries & Steel, Inc., Watervliet, N. Y.

Frank M. Robbins, Sr., has retired as president of Ross-Meehan Foundries, Chattanooga, Tenn., after 38 years with the company.

Eldon V. Romaine has resigned from the technical staff of the Pennsylvania Industrial Chemical Corp., New York City. Mr. Romaine has been active for many years in the work of Committee D-17 on Naval Stores, also has served on Committee D-1 on Paint.

(*Continued on page 87*)



No. 1470 AB HANDIMET GRINDER, complete $98.00

No. 1469-SW AB HANDIMET GRINDING PAPER for 1470 Grinder, Grits 240, 320, 400, 600 per 100....$10.00

No. 1469-1-SW AB HANDIMET GRINDING PAPER assorted 10 each grits 240, 320, 400, 600....$4.50

1470 AB

HANDIMET GRINDER

A New, Wet Hand Grinder for Metallurgical Samples

Now you may have wet grinding facilities for hand preparation in your laboratory at a nominal cost. Convenience at your fingertips, always clean and ready for use. Simply attach to water and drain facilities.

Individual elevated hard glass grinding surfaces are continually flushed with streams of water. This floats off the surface removal products, provides lubrication, and leaves sharp abrasive edges exposed at all times. A control valve permits complete selectivity of the volume of water. Ample drainage facilities with standard pipe fittings are provided at the rear. The grinding platforms are pitched downward and away from the operator.

The Handimet Grinding Paper is coated with a pressure sensitive adhesive backing and firmly holds when merely pressed against the flat grinding surface. It is easily removable when sheet is worn.

Buehler Ltd. METALLURGICAL APPARATUS

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FOR FURTHER INFORMATION CIRCLE 433 ON READER SERVICE CARD PAGE 105

FOR FURTHER INFORMATION CIRCLE 434 ON READER SERVICE CARD PAGE 105→

The most important announcement
in modern oscillograph history...
the dramatic new Honeywell direct-recording
VISICORDER®
All at once you can record and read the record of the Visicorder. Using a completely new direct-recording principle, the Visicorder puts six channels on a direct-reading record at sensitivities comparable to photographic oscillographs, and at frequencies from DC to 2000 cps!
VISICORDER
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HONEYWELL

THE **NEW** *VISICORDER,* perfected after years of research by the Heiland Division of Honeywell, combines the high frequency and high sensitivity characteristics of photographic oscillographs with the convenience of a direct-recording instrument.

By means of a completely new type of recording paper, light source, and optical system, the Visicorder makes use of mirror-type galvanometers to record phenomena from DC through 2000 cps *without* peaked amplifiers or other external compensation.

The record requires no liquids, vapors, powder magazines, or other processing materials. Development is accomplished by external light only as the record emerges from the oscillograph.

The Visicorder records are stable and require no further processing under normal conditions. They may be subjected to room light for extended periods without fading, and are permanent indefinitely when protected from light. Should it be necessary to subject the records to direct sunlight, they may be chemically "fixed" (in room light) using conventional photographic practices.

Visicorder records are reproducible by several methods using commercially available equipment.

Since the Visicorder operates on light-beam galvanometers, traces may deflect the full 6″ width of the chart, peak to peak, and their deflection is not limited by adjacent channels.

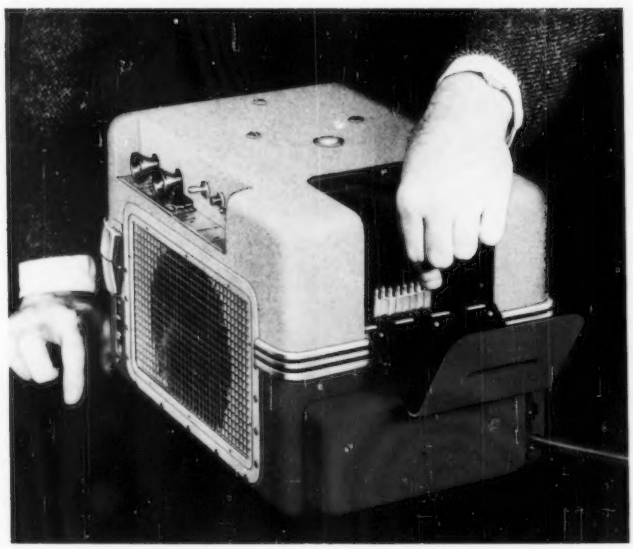
The remarkable exclusive features of the Visicorder make it the ideal recording oscillograph for applications where readable, permanent analog records are required and for additional uses where the measured phenomena need to be monitored or where immediate recorded results are desirable.

GENERAL FEATURES

FREQUENCIES	From DC to 2000 cps without peaked amplifiers or other compensation of any kind.
SENSITIVITIES	Comparable to photographic-type oscillographs.
RECORDING METHODS	Records directly on paper which requires no powder magazines, liquids, vapors, or other processing. Records are immediately visible and usable. Daylight loading. Accommodates recording paper 100 feet in length. Indicator shows unused recording paper available.
NO. OF CHANNELS	6 channels on 6″ wide paper plus provisions for two timing traces.
DEFLECTION	Full 6″ peak to peak. Traces may overlap; not limited by adjacent channels.
RECORD SPEEDS	0.2, 1, 5, and 25 inches per second, minute, or hour.
GALVANOMETERS	D'Arsonval-movement mirror galvanometers with choice of natural frequencies to suit individual requirements.
AMPLIFICATION	None required for most applications.
POWER	115 volt 60 cycle AC operation. 4 amperes.
DIMENSIONS	10″ height; 15″ depth; 10″ width.
WEIGHT	37 pounds, complete and ready to operate.
PRICE	$2,500.00, less galvanometers. Galvanometers $150.00 each.

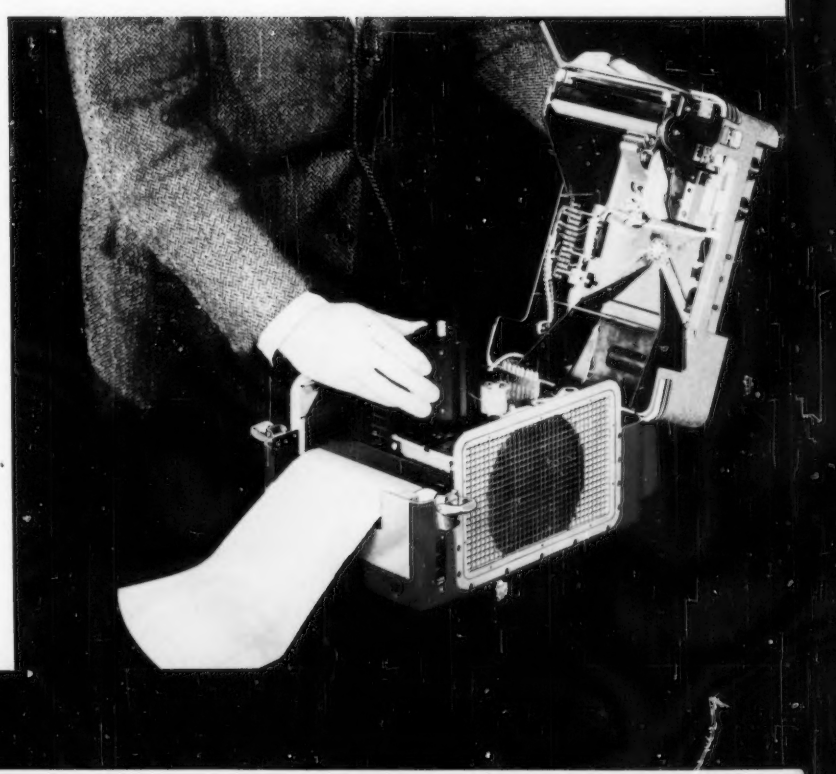
Deliveries starting January, 1957

❶ *THE VISICORDER* is the first and only photographic-type oscillograph that can be loaded with recording paper in daylight. The paper speeds can be selected while the instrument is in operation. The light spots from the galvanometers are *visible from the exterior* at their point of contact with the paper; thus phenomena can be monitored simultaneously with their recording.



❷ *GALVANOMETER ADJUSTMENTS* may be made through a panel-covered opening in the back of the instrument. Other operating controls —power on-off, lamp switch, paper drive and paper speed—are located on one convenient panel. Galvanometers are of the familiar Heiland solid-frame type: high sensitivity, accurate balance, high stability, low drift, in a versatile range of frequencies and sensitivities.

❸ *SERVICE* on the Visicorder is extremely easy, since the instrument opens completely as shown. All components—galvanometers, recording lamp, transmission—are completely accessible.



VISICORDER® APPLICATIONS

The versatile Visicorder will fit almost unlimited applications because of its high frequency and sensitivity characteristics, and because of its ease of operation.

In any application where instantaneous monitoring is needed, whether or not a record is desired, the Visicorder is ideal.

★ **In CONTROL** applications the Visicorder will continually monitor and record reference and error signals, and present an immediately available recording of information.

★ **In NUCLEAR** applications, the Visicorder will monitor and record temperatures, pressures, and all other phenomena needed.

★ **In PRODUCTION TEST** applications, the Visicorder will provide a final dynamic inspection of electrical and mechanical devices such as motors, relays, generators, governors, solenoid valves, etc., where high frequency response has been required, but unavailable in the past.

★ **In COMPUTING** applications, the Visicorder will provide immediately-readable analog recordings representing dynamic solutions at much higher frequencies than have ever been available via pen—and-ink-type recorders previously used for this work.

★ **In PILOT and COMPONENT TESTING,** the Visicorder will accomplish more rapid evaluation of design and prototypes than any other direct-writing oscillograph available.

★ **In MEDICAL** applications the Visicorder is useful for dynamic blood pressures, electrocardiograms, EEG, and other physiological measurements.

★ **In all TEST** applications the direct-recording features of the Visicorder are invaluable. Where complex tests involve the assembly of considerable equipment and the gathering of personnel, the immediate Visicorder record will prove the success of the test at once before the test equipment is dispersed.

For further information about the Visicorder, contact the Minneapolis-Honeywell Industrial Division Sales Office nearest you. Sales-service facilities in over 130 principal cities throughout the world.

700-C Series Recording Oscillographs
Galvanometers
Bridge Balance Units
Amplifier Systems
HEILAND Photo-Flash Equipment

MINNEAPOLIS
Honeywell
HEILAND INSTRUMENTS
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Personals

(*Continued from page 82*)

ASTM president **R. A. Schatzel** has accepted appointment as one of the industrial members of the Mohawk Valley Technical Institute board of trustees. Dr. Schatzel has been interested for many years in educational work. He has served as president of the Rome (N. Y.) Board of Education, and currently is president of the board of trustees of the Central New York School for the Deaf, Rome.

Bourdon F. Scribner of the National Bureau of Standards is 1957 chairman of the Chemical Society of Washington.

Vladimir L. Shipp, assistant to director, Technical Service Laboratories, Socony Mobil Oil Co., New York City, retired Dec. 1, 1956, after 26 years with the company. He will work as an independent petroleum and asphalt consultant with offices at 123 E. 37th St., New York City. Dr. Shipp has been active in ASTM as chairman of the Subsection on Development of Laboratory Methods for Predicting the Fluidity of Residual Fuel Oils (Research Division VII of Committee D-2 on Petroleum Products and Lubricants).

Gale C. Smith, formerly with J. H. Hinz Co., Cleveland, Ohio, is now associated with Archer-Daniels-Midland Co., of the same city, in the capacity of regional resin sales supervisor.

William J. Snoddon, until recently with Minnesota Mining and Mfg. Co., is now director of research, Yale Rubber Mfg. Co., Sandusky, Mich.

Albert P. Spooner metallurgical engineer, Bethlehem Steel Co., Bethlehem, Pa., received a Lehigh University alumni award for having "distinguished himself both by personal achievement and service as to bring lasting recognition and credit to himself and to Lehigh University." Affiliated with ASTM for the past 37 years Mr. Spooner has been very active in a number of the ferrous committees. He currently serves on the Advisory Committee of Committee A-1 on steel.

Harold R. Suter has been named technical director of J. B. Ford Div., Wyandotte Chemicals Corp.

Gordon Thompson, who has been chief engineer of Electrical Testing Laboratories, Inc., New York City, since 1945, has been elected vice-president. He has been with the enterprise since 1909, except for a seven-year period, 1920 to 1927, when he was professor of electrical engineering at Nanyang University, Shanghai, China.

H. D. Williams, formerly with the Ministry of Supply, AID Laboratories, recently joined Stanhope-Seta Limited, London, England, taking charge of the research and development division.

George M. Wyman, of Quartermaster Research and Development Center, Natick, Mass., has transferred to Army Research and Development liaison office, Frankfurt, Germany.

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...B-A Eagle Mount Spectrograph

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RESOLUTION

...when a monochromator is used as a spectrograph

BAIRD ATOMIC

3-Meter Spectrograph

EAGLE MOUNTING DESIGN

provides

- Truly high resolution over the entire focal curve on *every* exposure
- Complete absence of coma, distortion and slanting lines
- Astigmatic optical system produces more uniform spectral lines than stigmatic systems
- Entrance slit variations and dust in the slit have much less critical effect than in a stigmatic optical system
- Only one reflecting surface in the Eagle mount introduces less light loss, particularly in the far ultraviolet region
- Less scattered light, characteristic of Eagle Mounting Spectrographs, provides higher contrast between faint spectral lines and background

Baird-Atomic 3-Meter Spectrograph, a precalibrated instrument, permits all adjustments to be made from front control panel. Versatility, flexibility and faster analyses are possible.

For more specific data, your inquiry is invited.

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HOGGSON

TOOLS, MOLDS AND DIES

for rubber testing to ASTM standards

Compression Set—Method B

Composed of three plates 3" x 6" x 3/4", four compression screws and eight nuts, one set of six spacer bars 3/8" x 5/16" x 3". All parts chrome plated.

ONE OF MANY HOGGSON MOLDS AND DIES FOR MAKING STANDARDIZED TEST SAMPLES

The set at the left is only one of a wide variety of equipment we make for cutting and molding test samples of rubber, plastic or other synthetic materials for determining adhesion, abrasion, flexing, compression, rebound, etc.

These molds and dies are fabricated of high grade steel and precision finished to recognized ASTM standards of practice. If you will send us your blue prints or tell us what you need, we will send full details without obligation. We also manufacture a full line of production tools for working rubber and plastics.

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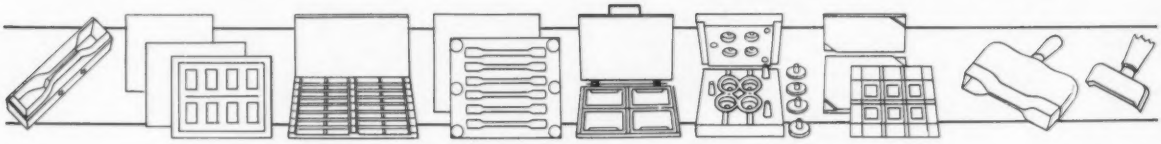

FOR FURTHER INFORMATION CIRCLE 436 ON READER SERVICE CARD PAGE 105

NEW MEMBERS.....

The following 118 members were elected from January 1 to January 15, 1957, making the total membership 8700 . . . . . Welcome to ASTM

Note—Names are arranged alphabetically—company members first then individuals—Your ASTM Year Book shows the areas covered by the respective Districts.

CHICAGO DISTRICT (5)

Maclean-Hunter Publishing Corp., George C. Lindsay, editor, 79 W. Monroe St., Chicago 4, Ill.

Midwest Job Galvanizers Assn., Fred C. Brightly, Jr., secretary-treasurer, Box 72 Chicago 50, Ill. [S]*

National Lock Co., William Geissman, assistant superintendent of finishing, Finishing Division, Rockford, Ill.

South Bend Modern Molding, Inc., John E. Borah, president, 815 E. Mishawaka Ave., Mishawaka, Ind.

Atkins, Clinton P., architect-engineer, Atkins, Barrow and Associates, 102 E. Main, Urbana, Ill.

Ballard, Robert L., metallurgist, Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.

Carlson, Clifton C., manager, fire research section, Research Department, Portland Cement Assn., 33 W. Grand Ave., Chicago 10, Ill. For mail: 4N-195 Ridgewood, Bensenville, Ill.

Danzer, Carl W., chemist, Modine Manufacturing Co., 1500 DeKoven Ave., Racine, Wis.

De Vries, Thomas, professor of analytical chemistry, Chemistry Dept., Purdue University, Lafayette, Ind.

Elstner, Richard C., structural development engineer, Structural Development Section, Portland Cement Assn., 33 W. Grand Ave., Chicago 10, Ill.

Fleischer, Herbert O., chief, division of timber processing, U. S. Forest Products Lab., Madison 5, Wis.

Hamel, Gayle E., engineering evaluation technologist, Minneapolis-Honeywell Regulator Co., 2600 Ridgeway Rd., Minneapolis, Minn. For mail: 1612 N. 6th St., Minneapolis 11, Minn. [A]**

Hoffmann, Max G. J., president, Chain Link Fence Corp., 4301 W. 69th St., Chicago 29, Ill.

Isenberg, Alfred H., research manager, Borden Co., Chemical Div., 3634 W. 38th St., Chicago 32, Ill.

Israel, Lon F., Jr., Engineering Dept., Whirlpool-Seeger Corp., La Porte Div., 229 Factory St., La Porte, Ind.

Kaupke, Mason M., principal and owner, Cedar Rapids Galvanizing Co., Cedar Rapids, Iowa.

Krishock, Raymond A., materials engineer, Hotpoint Co., Division of General Electric Co., 227 S. Seely Ave., Chicago 12, Ill. [A]

Massard, James M., research assistant professor of civil engineering, University of Illinois, Urbana, Ill. For mail: 116 Talbot Lab., Urbana, Ill. [A]

Ross, Bernd, chief physicist, Hoffman Semiconductor Div., Hoffman Electronics Corp., 930 Pitner Ave., Evanston, Ill.

Russell, W. B., consultant, Kewanee Boiler Division of American Radiator and Standard Sanitary Corp., 101 Franklin St., Kewanee, Ill.

Soles, Frank, works manager, H. K. Porter, Inc., of Pittsburgh, Delta-Star Electric Div., 2437 Fulton St., Chicago 12, Ill.

Wood, Leonard E., research engineer, School of Civil Engineering, Purdue University, Lafayette, Ind.

CLEVELAND DISTRICT (4)

Davis, Alden H., technical service engineer, Columbian Carbon Co., 452 E. Market St., Akron, Ohio.

Matter, Davis, manager, iron foundry service, Ohio Ferro Alloys Corp., 839 30th St., N. W., Canton 9, Ohio.

DETROIT DISTRICT (6)

McInerney Spring and Wire Co., Louis J. Silko, division manager, Mechanical Spring Div., 655 Godfrey Ave., S. W., Grand Rapids 2, Mich.

Anderson, Charles E., vice-president and treasurer, Galvanizers, Inc., 25425 Glendale Ave., Detroit 39, Mich.

NEW ENGLAND DISTRICT (13)

Hart Top Manufacturing Co., Inc., Rodney F. Ritter, laboratory director, 216 Appleton St., Holyoke, Mass.

Lawrence Leather Co., A. C., M. H. Battles, director of research, Peabody, Mass.

Goldberg, Albert, consulting engineer, Goldberg, LeMessurier and Associates, 669 Boylston St., Boston 16, Mass.

(Continued on page 90)

* [S] denotes sustaining member.
** [A] denotes associate members.

Now one unit does two jobs

The New Cenco® AUTOMATIC TITRATOR measures both mercaptans and olefins

Just by a change of electrodes and the flick of a switch, this one versatile instrument can measure both mercaptans and olefins . . . rapidly . . . accurately . . . and automatically. It's amazingly simple to operate—capable of titrating a wide range of concentrations without the use of standard solutions. And from 15 to 20 consecutive analyses can be run without an instrument adjustment. Reaction time registers in tenths of seconds directly on the Titrator.

Here's a dependable instrument, designed to economically increase efficiency in your laboratory operation. The unit is enclosed in a sturdy, compact metal case . . . finished in blue gray hammertone. The overall dimensions are 12″ x 12″ x 4½″.

The Cenco Automatic Titrator has been licensed under patent rights of the Standard Oil Company (Indiana).

No. 20928-1 Cenco Automatic Titrator, with electrodes for mercaptans—$565.00

No. 20928-2 Cenco Automatic Titrator with electrodes for olefins—$588.00

The combination instrument with both sets of electrodes, **$653.00**

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FOR PRECISION LABORATORY OR PRODUCTION TESTING

FREED
1110-AB INCREMENTAL INDUCTANCE BRIDGE
AND ACCESSORIES

Accurate inductance measurement with or without superimposed D.C., for all types of iron core components.

- INDUCTANCE — 1 Millihenry to 1000 Henry
- FREQUENCY — 20 to 10,000 Cycles
- ACCURACY — 1% to 1000 Cycle, 2% to 10KC
- CONDUCTANCE — 1 Micromho to 1 MHO
- "Q" — 0.5 to 100
- SUPERIMPOSED D.C. — Up to 1 Ampere
- DIRECT READING — For use by unskilled operators.

ACCESSORIES AVAILABLE:
1140-A Null Detector
1210-A Null Detector - V.T.V.M.
1170 D.C. Supply and 1180 A.C. Supply.

FREED
VARIABLE TEST VOLTAGE MEGOHMMETER NO. 1620

The Freed Type 1620 Megohmmeter is a versatile insulation resistance measurement instrument with a continuously variable DC test potential from 50 to 1000 volts.

Components such as transformers, motors, printed circuits, cables and insulation material can be tested at their rated voltage and above, for safety factor.

- Resistance — 0.1 megohms to 4,000,000 megohms.
- Voltage — variable, 50 - 1000 volts.
- Accurate — plus or minus 5% on all ranges.
- Simple — for use by unskilled operators.
- Safe — high voltage relay controlled.
- Self contained — AC operated.

OTHER MEGOHMMETERS AVAILABLE

Type 1620C MEGOHMMETER — a type 1620 with additional circuitry for testing capacitors.
Type 1020B MEGOHMMETER — a 500 volt fixed test potential. Range 1 megohm to 2 million megohms.
Type 2030 PORTABLE MEGOHMMETER — battery operated 500 volt test potential. Range 1 megohm to 10 million megohms.

Send for NEW 48 page transformer catalog. Also ask for complete laboratory test instrument catalog.

FREED TRANSFORMER CO., INC.
1733 WEIRFIELD ST., BROOKLYN (RIDGEWOOD) 27, N.Y.
CIRCLE 438 ON READER SERVICE CARD PAGE 105

New Members

(*Continued from page 88*)

Thayer, Richard S., assistant treasurer and director of purchases, The Macallen Co., Bay Rd., Newmarket, N. H.

Werdouschegg, Fritz M. K., pulp and paper chemist, Case Bros., Inc., Paper Mills, Manchester, Conn. For mail: 12 Strant St., Manchester 1, Conn. (A)

NEW YORK DISTRICT (1)

African Metals Corp., M. M. Bowman, vice-president, 25 Broad St., New York 4, N. Y.

Altmann International Corp., Bernhard, Herbert C. Haller, director of research, High Rock Mills, Inc., Philmont, N. Y.

American Hotel Assn., J. S. Fassett, director, Research and Service Dept., 221 W. 57th St., New York 19, N. Y.

Casein Importers Assn., Joseph Brown, representative, 2 Lexington Ave., New York, N. Y. For mail: 155 E. 44tn St., 25th fl., New York 17, N. Y.

Hitemp Wires, Inc., Michael Zangrillo, director, technical service, 26 Windsor Ave., Mineola, N. Y.

Hudson Chemical Corp., C. L. Wilson, director of research, Lake Ave. and Saw Mill River Rd., Yonkers, N. Y.

Humphrey-Wilkinson, Inc., B. J. Humphrey, President, Devine St., North Haven, Conn.

Lycoming Division, Avco Manufacturing Corp., T. G. McNamara, chief metallurgist, 550 Main St., Stratford, Conn.

Narrow Fabrics Inst., Penn Affiliates, managers, 11 W. 42nd St., Room 2856, New York 36, N. Y.

Saybolt & Co., E. W., Joseph H. McCabe, partner, 265 Bayway, Elizabeth 2, N. J.

Saybolt & Co. S. A., E. W., Panama City, Panama, J. H. McCabe, Jr., president, 265 Bayway, Elizabeth 2, N. J.

Sensitive Research Instrument Corp., H. Russell Brownell, chief engineer, 310 Main St., New Rochelle, N. Y.

United States Mineral Wool Co., Frank M. Stumpf, director of research, Stanhope, N. J.

Andrews, Emma D., Librarian, Radio Corporation of America, Semicondutor Div., Somerville, N. J.

Brown, Joseph, sales manager, The Tupman Thurlow Co., Inc., 155 E. 44th St., New York 17, N. Y. For mail: 13 Mary Lane, Greenvale, N. Y.

Coe, John M., chief of structural application, Grumman Aircraft Engineering Corp., Plant 5, Bethpage, N. Y.

Davis, Calvin, assistant manager of technical services, Atomic Industrial Forum, Inc., 3 E. 54th St., New York 22, N. Y.

Dorsey, James, chief mechanical engineer, Larc Products, Inc., Box 327, Amsterdam, N. Y. For mail: 37 Phillips St., Amsterdam, N. Y. [A]

Jelenffy, Michal, destructive and nondestructive testing engineer, 1381 York Ave., New York 21, N. Y.

Randolph, Wendell G., Randolph Products Co., Box 57, Carlstadt, N. J.

St. Lawrence Seaway Development Corp., Box 213, Massena, N. Y.

Zasimovich, John G., process engineer, The California Oil Co., 1200 State St., Perth Amboy, N. J. For mail: 16 Paulus Blvd., New Brunswick, N. J. [A]

NORTHERN CALIFORNIA DISTRICT (8)

Klein, Alexander, research engineer and lecturer in civil engineering, University of California, Berkeley, Calif. For mail: 210EML, University of California, Berkeley, Calif.

Schniewind, Arno P., Division of Timber Physics and Mechanics, University of California, Forest Products Lab., 1301 S. 46th St., Richmond 4, Calif. [A]

OHIO VALLEY DISTRICT (15)

Arvin Industries, Inc., John Brighton, chief engineer, 13th St., Columbus, Ind.

Famco, Inc., Robert P. McCarthy, research chemist, Box 35, Highland Park Station, Louisville 9, Ky.

Keifer, B. F., engineer, State Highway Testing Laboratory, Ohio State University, Columbus 10, Ohio.

Mullin, Keith B., chemist, Celanese Corporation of America, Gallipolis Ferry, W. Va. [A]

PHILADELPHIA DISTRICT (2)

All American Engineering Co., M. O. Young, chief draftsman, DuPont Airport, Box USS 2668, Wilmington 5, Del.

Fisher, Sallie A., chemist, Rohm & Haas Co., 5000 Richmond St., Philadelphia 37, Pa. For mail: 45 Maple Lane, Levittown, Pa.

Meynen, Philip George, teaching assistant, Department of Civil Engineering, Fritz Lab., Lehigh University, Bethlehem, Pa. [A]

Reburn, J. Clyde, metallurgist, Lansdowne Steel and Iron Co., Morton, Pa.

Theel, Percival, director of research, Philadelphia Textile Inst., Henry Ave. & Schoolhouse Lane, Philadelphia 44, Pa.

Wilson, S. A., assistant chief engineer. Bethlehem Steel Co., Inc., Bethlehem, Pa.

Zarembo, John E., supervisor, General Analytical Section, Food Machinery and Chemical Corp., Chemical Div., Box 8, Princeton, N. J.

PITTSBURGH DISTRICT (3)

Buchoff, Leonard S., chemical engineer, Westinghouse Electric Corp., 356 Collins Ave., Pittsburgh 6, Pa. [A]

Daniels, Cloyce R., chief chemist, Esso Standard Oil Co., 34th and Smallman Sts., Pittsburgh 1, Pa.

Gorman, Harold R., lubrication engineer, Pittsburgh Plate Glass Co., Glass Division Research Lab., Creighton, Pa.

Rickett, Reginald L., assistant director, E. C. Bain Laboratory for Fundamental Research, U. S. Steel Corp., Monroeville, Pa.

ST. LOUIS DISTRICT (9)

Southwest Grease and Oil Co., Inc., M. L. Carter, treasurer and chief chemist, 220 W. Waterman St., Wichita 2, Kans.

Bennett, James Lawton, chairman, engineering drawing, Junior College of Kansas City, Mo., 3545 McGee St., Kansas City 11, Mo. For mail: 12 E. 52nd St., Kansas City 12, Mo.

Hancock, Kenneth R., head, Research and Development Dept., C. K. Williams and Co., 2001 Lynch St., East St. Louis, Ill.

Rulfs, Carl H., chief mechanical engineer, Union Electric Co., Engineering and Construction Dept., 315 N. 12th Blvd., St. Louis 1, Mo.

SOUTHERN CALIFORNIA DISTRICT (7)

Beckman, Arnold O., Inc., M. W. Greene, senior research engineer, 1020 Mission St., South Pasadena, Calif.

Convair, A Division of General Dynamics Corp., C. S. Brandt, design specialist, San Diego 12, Calif.

Whittaker Gyro Division of Telecomputing Corp., H. L. Stewart, process engineer, 16217 Lindbergh St., Van Nuys, Calif.

Clark, Kenneth L., technical representative, The International Nickel Co., Inc., West Coast Technical Section, 538 Petroleum Bldg., Los Angeles 15, Calif.

Cummins, Neil J., civil engineer, 1804 Saviers Rd., Oxnard, Calif.

Fox, Raymond R., senior designer, C. F. Braun and Co., 1000 S. Fremont Ave., Alhambra, Calif.

Geiger, Lawrence J., chemist, Amercoat Corp., 4809 Firestone Bldg., South Gate, Calif.

Holcomb, Lowell A., test engineer, Mechanical Test Lab., Convair, A Division of General Dynamics Corp., Pomona, Calif. For mail: 10083 Belair Ave., Ontario, Calif.

Jenkins, George L., member, technical staff, Hughes Aircraft Co., Culver City, Calif. For mail: 323 S. Helena St., Anaheim, Calif. [A]

McCarthy, Bernard Y., regional manager, Research and Technical Dept., The Texas Company, 929 S. Broadway, Los Angeles 15, Calif.

SOUTHWEST DISTRICT (16)

McEvoy Co., E. C. Fowler, chief inspector, Box 3127, Houston 1, Tex.
Well Surveys, Inc., George E. Sykora, works manager, Box 2656, Tulsa 3, Okla.
Golden, James A., shop superintendent, S & R Tool and Supply Co., Box 1755, Houston 1, Tex. For mail: 541 Shotwell, Houston 20, Tex.
Jamison, W. H., chemical engineer, Tennessee Gas Transmission Co., 1401 N. Rice Ave., Bellaire, Tex.
Jones, Kenneth E., chief engineer, Joe Stine, Inc., 6022 Chocolate Bayou Rd., Houston, Tex. For mail: Box 14471, Houston 21, Tex.
McAtee, James L., Jr., supervisor, Technical Service Labs., Baroid Div., National Lead Co., Box 1675, Houston 1, Tex.
Moore, Walter P., consulting engineer, 2 Pinedale, Houston 6, Tex.
Moutrey, Curtis E., operations consultant, Curtis E. Moutrey and Associates, Box 6005, Tulsa 6, Okla.
Schaumburg, George J., owner, George J. Schaumburg, Consulting Engineers, 2678 Laurel Ave., Beaumont, Tex.

WASHINGTON, D. C., DISTRICT (14)

Aderholdt, Daniel F., chief chemist, State Water Control Board, 415 W. Franklin St., Richmond 20, Va.
Bost, C. S., sales development engineer, Celanese Corporation of America, Box 1414, Charlotte, N. C. [A]
Ewald, George W., manager, Industrial Sales Dept., Celanese Corporation of America, Box 1414, Charlotte, N. C.
King, Maurice A., Jr., quality control supervisor, Albemarle Paper Manufacturing Co., Tredegar St., Richmond 17, Va. [A]

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Canadian General Electric Co., Ltd., E. A. Atkinson, insulation specialist, Industrial Products Dept., Davenport Works, 940 Lansdowne Ave., Toronto, Ont., Canada.
Erskine Precision Wire Corp., Franklin L. Conner, engineer, Box 309, Emporium, Pa.
Mead, Henry E., Sr., superintendent of galvanizing, Provincial Engineering, Ltd., 647 Ferguson St., Niagara Falls, Ont., Canada.

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Miami Water Clinic, C. W. Curtis, technical director, 965 S. W. 8th St., Miami 36, Fla.
Gill, William P., partner, Deerfield Sand Co., Co., Box 207, Ridgeland, S. C. [A]
Spigolon, Silvio J., assistant professor of civil engineering, University of Mississippi, University, Miss. [A]
Stromquist, Donald M., technical representative, U. S. Steel Corp., Coal Chemical Sales Div., 919 Kearns Bldg., Salt Lake City, Utah.
Wilson, Stanley D., partner, Shannon & Wilson, 2208 Market St., Seattle 7, Wash.

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Asgeirsson, Haraldur, University Research Inst., Reykjavik, Iceland.
Christian, Walter, chief of quality control organization, Philips do Brazil, São Paulo, Brazil. For mail: Caixa Postal 12470—Ipiranga, São Paulo, Brazil.
Gassner, Ernst, research engineer, Laboratorium Fuer Betriebsfestigkeit, Darmstadt-Eberstadt, Muehltalstrasse 55–57, Germany.
Guettinger, Hans August, chief of laboratory, Everite (Pty.), Ltd., P. O. Kliprivier, Transvaal, Union of South Africa.
Hansen, Victor E., refinery manager, Northern Petroleum Corp., Ltd., Kamsack, Sask., Canada.
Istituto Dinamometrico Italiano, Via Onorato Vigliani 104, Torino, Italy.
Koh, Michael C., Standard-Vacuum Oil Co., Operation Dept., Union Bldg., Singapore 1, Malaya. [A]
Quebec Hydro Electric Commission, J. W. McCammon, general manager, 107 Craig St. W., Montreal, P. Q., Canada.
Rodriguez Pena, D. Valentin, Apartado, 7, Aviles-Asturias, Spain.
Snowden, Charles E., Jr., mechanical engineer, Okinawa Engineer District, Box 7, Sukiran Post Office, APO 331, c/o Postmaster, San Francisco, Calif.

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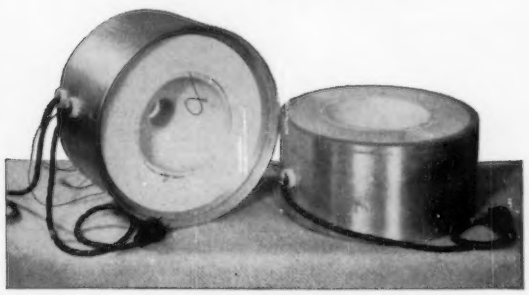
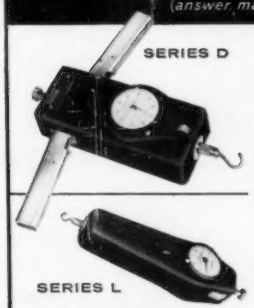


CIRCLE 439 ON READER SERVICE CARD PAGE 105

PRECISION FORCE GAGES
(answer many test standard requirements)



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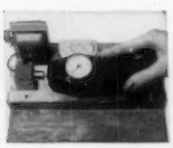

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CIRCLE 440 ON READER SERVICE CARD PAGE 105

New Standard Samples for Rubber Compounding

THE NATIONAL BUREAU OF STANDARDS has added two synthetic rubbers to its list of standard materials for rubber compounding: styrene-butadiene rubbers types 1000 and 1500, the first rubbers issued as standard samples.

A total of 15 standard samples for rubber compounding (Table I) are now available from the Bureau. This series, initiated in 1948, consisted originally of seven compounding ingredients used in the quality control of synthetic rubber production. Later ASTM's Committee D-11 on Rubber and Rubberlike Materials requested the Bureau to prepare additional standard samples for use in testing and quality control of other raw materials. This committee also sponsored the establishment of one of the new standard samples, rubber type 1500.

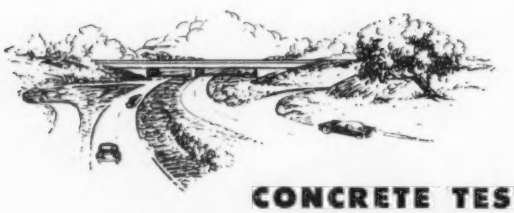
The two synthetic rubber samples are copolymers of styrene and butadiene. Type 1000 is polymerized at 50 C and 1500 at 6 C. They are used as reference standards in the formulations given in ASTM Methods D 15 and in specifications for synthetic rubbers. Designated as Standard Samples 386 and 387, they are available in bales of about 75 lb priced at $24 for type 1000 and $27 for type 1500.

The preparation of the standard samples for rubber compounding has necessitated the development of special laboratory processing and testing equipment. Special mill rolls were designed and constructed for maintaining uniform surface temperature during mixing of the rubber compound. The mold used for curing the rubber at NBS was machined directly into the hot plates of the vulcanizing press and controls were installed for keeping the temperature during vulcanization within 0.1 C. Improvements were also made in the Mooney viscometer and a strain tester was developed to attain the necessary test precision.

TABLE I.—NBS STANDARD SAMPLES FOR RUBBER COMPOUNDING.

Number	Name	Approx. weight of sample, g	Price per sample
370	Zinc oxide	2000	$2.15
371	Sulfur	1400	1.75
372	Stearic acid	600	1.90
373	Benzothiazyl disulfide	500	1.75
374	Tetramethylthiuram disulfide	500	3.50
375	Channel black	7500	3.50
376	Light magnesia	450	2.40
377	Phenyl beta-naphthylamine	600	4.00
378	Oil furnace black	7000	3.50
379	Conducting black	5500	3.50
380	Calcium carbonate	6000	2.50
381	Calcium silicate	4000	2.50
382	Gas furnace black	7500	3.50
386	Styrene-butadiene rubber, type 1500	34000	27.00
387[a]	Styrene-butadiene rubber, type 1000	34000	23.00

[a] This sample is the remainder of reference rubber X-768 GR-S established in 1955 by the Federal Facilities Corp., Office of Synthetic Rubber.



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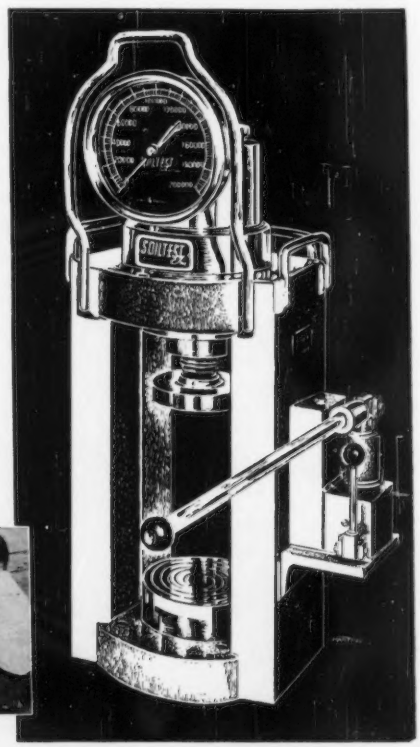

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FOR FURTHER INFORMATION CIRCLE 441 ON READER SERVICE CARD PAGE 105

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H-1823—Balance, Analytical, Becker Model "AB-2." Two Pan. Dial reading, chainomatic, with notched beam. Capacity — 200 grams. Sensitivity—1/20 mg. Request bulletin CBC-2.
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H-2130—Balance, Mikrowa. Large capacity—2Kg. Direct Reading to 50 grams. Rapid weighing. Request bulletin MFW-30.
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H-1640—Balance, Analytical, Ainsworth "Right-A-Weigh," Type S. Capacity—200 grams. Sensitivity—1/10 mg. Single Pan. *No weight handling.* Features substitution weighing. Request bulletin ARA 200.
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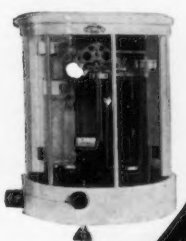

H-2400

H-2400—Balance, Analytical, Sartorius "Projecta Rapid" Model. Capacity—200 grams. Sensitivity—1/20 mg. Two Pan. *No weight handling up to 10 grams* (weights up to 10 grams are built-in). Request bulletin SPR-1.
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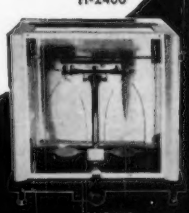

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FOR FURTHER INFORMATION CIRCLE 442 ON READER SERVICE CARD PAGE 105

DEATHS...

S. A. Brazier, technical manager, Dunlop Rubber Co., Ltd., General Rubber Goods Div., Manchester, England. Representative of company membership since 1945; also member of Committees D-11 on Rubber and Rubber-Like Materials and D-14 on Adhesives.

A. Oram Fulton, president and Treasurer, Wheelock, Lovejoy & Co., Inc., Cambridge, Mass. (Feb. 20, 1956). Member since 1925.

G. S. Hallenbeck, president, Hallenbeck Inspection & Testing Laboratory, Buffalo, N. Y. Member since 1928; served on Western New York-Ontario District Council 1953–1955.

Harry R. Lever, general manager, Power Engineering and Equipment Co., Torrance, Calif. Member since 1956.

James B. Macelwane, dean, Institute of Geophysical Technology, St. Louis University, St. Louis, Mo. Member since 1948.

George W. Saathoff, consulting engineer, Hoboken, N. J. (Nov. 10, 1956). Member since 1924.

M. M. Schlissel, chief chemist, Metropolitan Refining Co., Inc., Long Island City, N. Y. (February 29, 1956). Member since 1934.

Harry Roscoe Wolf (retired), Executive Department, Research Laboratories Div., General Motors Corp., Detroit, Mich.; residence, 21500 Olmstead, Dearborn, Mich. (Jan. 8, 1957). A member of the Society since 1913, Mr. Wolf had been active in many of the technical groups through the years. He had served on Committees A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, C-14 on Glass and Glass Products, D-11 on Rubber and Rubber-Like Materials, D-13 on Textile Materials, and the ASA Sectional Committee Z-26 on Safety Glazing Materials. His most extensive service, however, was in Committee D-2 on Petroleum Products and Lubricants, where he had headed many subgroups, and in D-15 on Engine Antifreezes, of which he was a charter member and the first chairman (1947–1956). He was responsible for many developments ultimately beneficial to industry and mankind in the field of engine antifreezes. During his early research work (with General Motors Corp.) he established a relationship between temperature aeration and corrosion tendencies within antifreeze systems. He was instrumental in setting up the General Motors simulated test method which was used as the basis for the present ASTM evaluation work. He presented many technical papers on problems related to the automotive industry, including antifreezes, brake linings, lubrication, and motor fuels.

Mr. Wolf was granted an ASTM Award of Merit in 1956, in recognition of long-time valued service, especially supporting standardization and research work in Committee D-2, and as charter chairman of Committee D-15.

Although Mr. Wolf had been suffering for some time from leukemia, his passing was rather unexpected as he had been up and around recently. He attended a meeting of Committee D-15 in November, also a meeting of the Detroit District (he had served as a District Councilor for several years). He was recognized at the dinner as having received the Award of Merit earlier in the year. He will be especially missed by the D-15 members, which group had offered a "Tribute of Appreciation" to him in March, 1956 in recognition of outstanding leadership, noting "his wise counsel, scientific integrity, and the high regard of his friends and associates."

At the time of his retirement from General Motors in December, 1956, Mr. Wolf had completed 44 years of service with the company. His other organizational affiliations included the American Chemical Society and the Society of Automotive Engineers.

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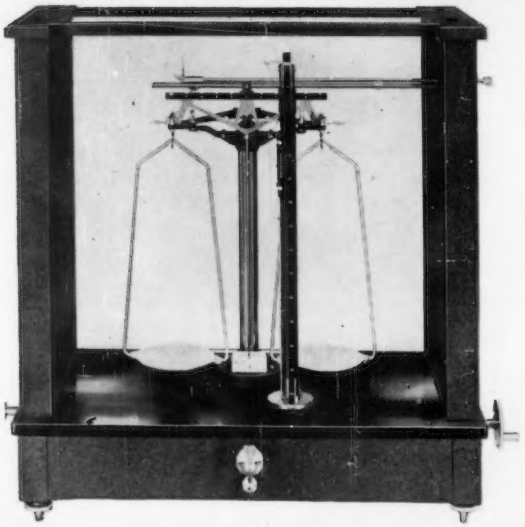

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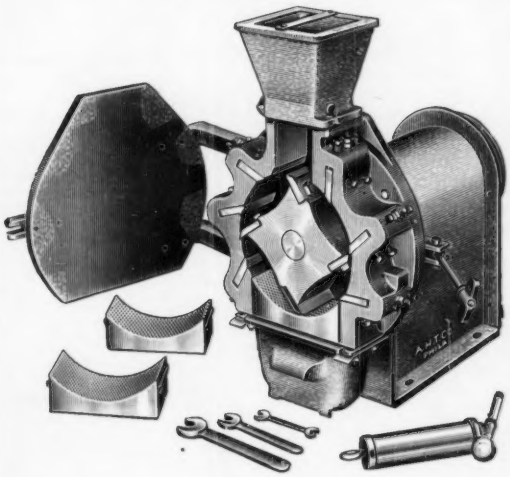

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As in earlier model, four hardened steel knives on revolving shaft work with shearing action against six knives bolted into frame. Shearing action of cutting edges, between which there is always clearance, minimizes loss of moisture, avoids temperature rise, liquefaction, contamination, etc., making this mill satisfactory for many materials which can not be reduced by other mechanical means. Ground material must pass through a sieve dovetailed into frame.

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4274-V. Ditto, but with drawer in place of chute and jars; without motor or base..... 567.00

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NEWS NOTES ON

Laboratory Supplies and Testing Equipment

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Lo-Boy Chilling Chamber—A new low-temperature chilling machine, 24 in. high, has been developed to chill metal specimens for impact testing. Known as Model LA-120-2, the new machine permits control of temperatures from +25 F to −135 F for a wide range of experimentation. It moves easily to any location on four swivel-type rubber casters for laboratory convenience.
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Consolidated Electrodynamics Corp. 1300

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(*Continued on page 98*)

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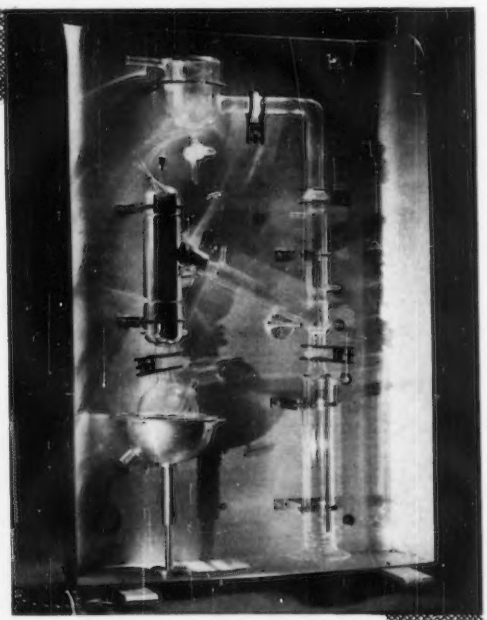


Unitized ASTM vacuum-distillation unit for running reduced-pressure distillations of petroleum products according to Method D-1160-52T.

FOR FURTHER INFORMATION CIRCLE 446 ON READER SERVICE CARD PAGE 105

QUALITY INSTRUMENTS FOR QUALITY CONTROL

BURSTING STRENGTH ✓
- PAPER (D 774) ☐
- FABRICS (D 76) ☐
- (D 751) ☐
- PAPER BOARD ☐
- PLASTIC FILM ☐

HYDROSTATIC RESISTANCE
- COATED FABRIC (D 751) ☐

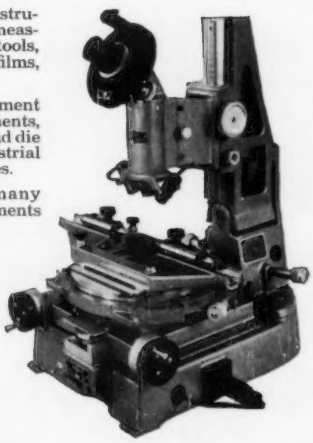
BOND STRENGTH
- RESIN COATING TO PAPER ☐

FOR INFORMATION CHECK THE INSTRUMENT IN WHICH YOU ARE INTERESTED AND MAIL ON YOUR LETTERHEAD TO

B. F. PERKINS & SON INC.
TESTER DIV. HOLYOKE, MASS.

CIRCLE 447 ON READER SERVICE CARD PAGE 105

Precise measurement to 0.0001" and 1 minute of arc with Gaertner Toolmakers' Microscope



- Versatile, easy-to-use instrument for indisputable measurement of piece parts, tools, dies, jigs, fixtures, films, plates, etc.
- Basic measuring instrument for inspection departments, gage laboratories, tool and die and model shops, industrial and research laboratories.
- Does the work of many "single-purpose" instruments with greater accuracy and convenience.
- Co-ordinate range 4" x 2".
- Independently rotatable cross hairs.
- Low, compact, built-in rotary stage.
- Full 2" precision-lapped lead screws with correction device.
- Thread and radius templates, camera and spotting attachments, fine motion focus, variable magnification available to suit your specific requirements.

SEND FOR FREE BULLETIN 147-50

The Gaertner Scientific Corporation
1215 Wrightwood Ave., Chicago 14, Ill.
Telephone: BUckingham 1-5335
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ACCURACY IN TEST RESULTS

is greatly increased by positive control of specimen temperatures

in the Model DMC WEATHER-OMETER®

A constant volume of air at a controlled temperature in the heavily insulated cabinet, maintains uniform predetermined specimen temperatures regardless of variations in room conditions.

Automatic control of humidities up to dew point is available as optional equipment.

All automatic controls are located on the front panel of the Weather-Ometer directly above the door of the test chamber.

Both horizontal and vertical testing is available. Shallow containers are used for semi-liquid materials and vertical panels for solid materials.

Source of radiation is two Atlas enclosed violet carbon arcs.

Complete technical information on the DMC Model and other Weather-Ometers is contained in the new Weather-Ometer catalog. Copy on request.

FADE-OMETER®

The Atlas Fade-Ometer has world-wide acceptance as the standard machine for testing the action of sunlight on materials.

A wide range of industrial products are tested daily in Atlas Fade-Ometers to determine the deterioration of materials due to the action of sunlight.

From 21 to 126 samples, depending on size, can be simultaneously exposed to the light of the Atlas Enclosed Carbon Arc. Temperature is controlled automatically and humidity is furnished by evaporation from a constant water reservoir. Operation of the Fade-Ometer is completely automatic, permitting the machine to be left in continuous 24-hour operation.

The Carbon Arc Lamp in the Fade-Ometer is the closest known duplicate of sunlight, both as to intensity and spectral distribution.

If your product is subject to deterioration by sunlight our engineers, with over a quarter of a century of experience in predetermining the fading of materials, can help you.

Catalog with technical information on request

ATLAS ELECTRIC DEVICES COMPANY
4114 N. Ravenswood Ave., Chicago 13, Ill.
Manufacturers of accelerated testing equipment for over a quarter of a century.

CIRCLE 449 ON READER SERVICE CARD PAGE 105

Lab Items

(*Continued from page 96*)

operated corrosion tester. With battery operation it can be used successfully in the field or in the lab.
Labline, Inc. 1305

Extractor—A practical apparatus for countercurrent distribution, using three-phase solvent system combinations, has been released.
Laboratory Glass & Instrument Corp. 1306

Water Bath—A new apparatus for operating laboratory water baths has been announced. Called the Tempunit, it combines in one piece of apparatus a self-contained heater, controller, stirrer, and circulator with a completely built-in pneumatic control system.
Arthur S. LaPine & Co. 1307

Sonic Analyzer—Spectrum analysis of sounds, vibrations, and electrical waveforms for laboratory operations.
Panoramic Radio Products, Inc. 1308

Elastomer Tester—A new tester for aging of elastomers at temperatures up to 1000 F has been announced. Developed for evaluating usefulness and endurance of rubber and plastic compounds at the elevated temperatures encountered in modern applications.
Scott Testers, Inc. 1309

Soil Compaction—A new mechanical soil compactor eliminates hand compaction process and produces uniform results. The compaction test is performed to determine a soils moisture-density relationship and the maximum density to which a construction fill or subgrade material should be compacted.
Soiltest, Inc. 1310

Temperature Test Chamber—A new temperature test chamber for ambient testing of products up to 600 F has been developed. This model, identified as the Statham Model TC-4, with temperature testing ranges from −65 to 600 F, has a product capacity of 600 cu in. of working space.
Statham Development Corp. 1311

Thermistor Radiometer—A wide range thermistor radiometer for the direct measurement of surface temperatures permits relative or absolute temperature readings from surfaces for environmental studies.
Williamson Development Co., Inc. 1312

CATALOGS & LITERATURE

Stainless Steel Honeycomb—Bibliography gives the titles and publication references of articles published since 1950 on fabrication and testing.
American Silver Co., Inc. 2191

Tape Recorder—Capabilities and characteristics of an instrumentation tape recorder are described in an attractive, 20-page booklet. Detailed specifications are also provided in the booklet which is printed in four colors.
Ampex Corp. 2192

New Price List on SR-4 Devices—A new line of flat grid, fine pitch, bakelite gages is among the new products listed in the new price list on SR-4 strain gages, instruments, and accessories.
Baldwin-Lima-Hamilton Corp. 2193

Cenco News Chats—*No. 83* contains descriptions and photos of new and redesigned instruments and apparatus for laboratory use.
Central Scientific Co. 2194

Heteropolymolybdates—*Properties of Heteropolymolybdates*, a 15-page bulletin for research and development chemists covering the properties, uses, classification, nomenclature, and preparation of heteropolymolybdates, and containing a section on the use of literature on these compounds, has been published.
Climax Molybdenum Co. 2195

The Laboratory—New development laboratory instrumentation and technique are described and illustrated in the latest number of *The Laboratory*, Vol. 25, No. 4.
Fisher Scientific Co. 2196

Variac Autotransformer—New 24-page *Bulletin O* describing the complete line of Variac adjustable autotransformers. Dimension drawings, in addition to photographs, are included for all models, and complete specifications and prices are tabulated.
General Radio Co. 2197

Combustion Testing—A new bulletin, *Bulletin No. 38*, illustrating and describing a line of gas pressure manometers, oil flow graduates, sling psychrometers, etc., is available upon request.
General Scientific Equipment. Co. 2198

Laboratory Glass—New catalog of products for the wet laboratory includes illustrations, data tabulations, and price information on the full range of Glenlab products available.
Glass Engineering Labs. 2199

Thermopiles—A 12-page brochure describing thermopiles for conversion of infrared energy into electrical energy suitable for amplification and measurement has been announced.
Jarrell-Ash Co. 2200

Potentiometer—A new six-page *Data Sheet E-51(6)* describing the Type K-3 Universal (Guarded) Potentiometer is now available.
Leeds & Northrup Co. 2201

New Bulletin—16-page bulletin includes new laboratory apparatus such as a flask heater with interchangeable baskets, a pocket size pH meter, a continuous extractor for work with solvents heavier than water, etc., is available.
Schaar & Co. 2202

What's New—The 27th edition of 24 pages "What's New for the Laboratory" is now available.
Scientific Glass Apparatus 2203

INSTRUMENT COMPANY NEWS

Applied Research Labs., Glendale, Calif.—The Bausch & Lomb Optical Co. has appointed Applied Research Labs., Glendale, Calif., as dealer for the B&L line of spectrographs and associated equipment.

BURRELL "For Scientists Everywhere"

New! UNIVERSAL MODEL K-3

KROMO-TOG®

For Gas and Vapor-Phase CHROMATOGRAPHY

- Routine Analysis in Any Laboratory!
- Process Control in Manufacturing!

Bench or panel-mount anywhere . . . uses metal columns of various lengths . . . analyzes gases or liquids, even liquids boiling up to 300°C.

Fractions collected easily, individual temperature control of cell and columns, finest detector cell available and other exclusive Burrell features. You'll get unexpected accuracy and thoroughness far faster than ever before.

COMPACT SIZE
Only 24" x 16" x 13"

BUILD-UP DESIGN
Accessories can be added to basic unit

NEW LOW PRICE

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Scientific Apparatus and Laboratory Supplies
2223 Fifth Avenue, Pittsburgh 19, Pennsylvania

CIRCLE 450 ON READER SERVICE CARD PAGE 105

Beckman Instruments, Inc., Fullerton Calif.—The Scientific Instruments Div. has announced the leasing of a new 20,000 sq ft plant in Anaheim, Calif. Need for the new facility is based on the continuing rapid expansion of the division in the field of industrial data and control systems.

Bendix Aviation Corp., Baltimore, Md.—Recently entered into a contract to acquire the business and asserts of the Sheffield Corp., Dayton, Ohio, a privately owned company which is one of the major manufacturers of precision gaging and measurement instruments, and industrial inspection and quality control systems.

Horizons, Inc., Cleveland, Ohio—A major expansion in its services and facilities has been announced by this Cleveland materials and process research organization. Because of a greatly increasing demand, certain specialized research facilities are now available to industry on a service contract basis. For the first time, Horizons will make such services available to industry in general, to enable it to obtain the benefits from highly specialized testing facilities and techniques not generally available in industrial laboratories.

Magnaflux Corp., Chicago, Ill.—The Board of Directors have elected Roy O. Schiebel to the position of 2nd vice-president of the corporation. The election fills the newly created position: 2nd vice-president, sales and marketing.

MB Mfg. Co., New Haven, Conn.—A complex-motion compensation console built by this division of Textron, Inc., for vibration research and development in guided missiles and supersonic aircraft, was demonstrated at the company's main plant in New Haven, Conn.

Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.—Ralph L. Goetzenberger of Washington, D. C., a vice-president for the past 22 years, has resigned upon reaching the voluntary retirement age of 65.

Robertshaw-Fulton Controls, Philadelphia, Pa.—A modern $2-million manufacturing plant, more than doubling the size and output of the installation it replaces, was officially opened by the Bridgeport Thermostat Div. of Robertshaw-Fulton Controls Co. The 180,000 sq ft plant, on a 15-acre site in Milford, Conn., represents one of the largest manufacturing installations in the area. Complex precision instruments and components for use in industry and jet aircraft are being produced in the manufacturing facility.

Robertshaw-Fulton Controls, Philadelphia, Pa.—Has acquired the Beta Corp., Richmond, Va., manufacturers of specialized vibration monitoring equipment. Beta Corporation's operation will be moved to Philadelphia and consolidated with the Fielden Instrument Div., a unit of Robertshaw-Fulton.

NEWS OF LABORATORIES

Bart Mfg. Corp., Belleville, N. J.—S. G. Bart, president, recently announced the purchase of all outstanding stock of the Bart Mfg. Corp., including the Bart Laboratories Div., as well as the stock of Electroplating Design, Inc., The Design and Chemical Research Co. No change of address or policy is anticipated for either company.

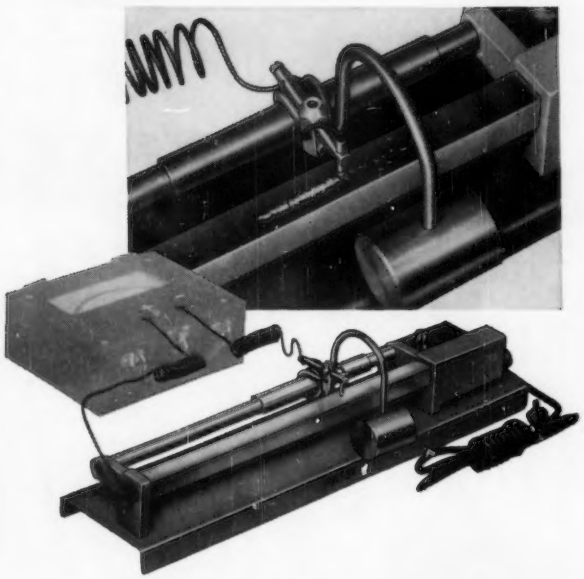
Electrical Testing Labs., Inc., New York, N. Y.—Announces the election of Hoffman Stone Beagle as president. Mr. Beagle joined ETL in 1953 as assistant to the president and became executive vice-president in 1956.

Electrical Testing Labs., Inc., New York N. Y.—Announces a new $40,000 facility for the testing and evaluation of room air conditioners. The new facility is the first of its kind available to the industry and enables independent, authoritative determination of product ratings according to today's standards. It accommodates units rated up to 20,000 Btu and marks the most recent development in ETL's 23 years of service to manufacturers and dealers of air conditioners.

Foster D. Snell, Inc., New York, N. Y.—Foster Dee Snell, president and chairman of the board, announced the purchase of Seil, Putt and Rusby, Inc., Chemical Consultants, 16 E. 34th St., New York City. Stephen S. Voris, president of Seil, Putt and Rusby, Inc., will join the parent organization as director of the new subsidiary. All other employees will also join Snell.

Parr

The Improved
MELTING POINT APPARATUS



- **Series 3821 — Dennis Type**

Here is a rapid and reliable instrument for testing any material having a distinct melting point at temperatures between 50 and 250 degrees Centigrade.

A one inch square bar of solid copper, silver coated and with an electric heater and thermoregulator at one end forms the heated stage of the Series 3821 apparatus. A wide range of test temperatures is always available on the 17-inch bar. A thin train of sample laid on the surface will melt at a definite spot. The temperature at this spot is determined by touching it with a constantan wire pointer, thereby forming a copper-constantan thermocouple. Several readings can be taken quickly with the same sample, and the sample can be recovered if desired.

The ruggedness and simplicity of earlier models are retained in this improved apparatus, while the addition of a new pointer and slide carrier insures smooth operation with uniform contact pressure for reproducible temperature readings.

Ask your Parr Dealer for prices or write direct for Spec. 3821.

PARR INSTRUMENT CO. MOLINE, ILL.

FOR FURTHER INFORMATION CIRCLE 451 ON READER SERVICE CARD PAGE 105

A SLIP of the linotype machine resulting in an index reference to Tests for Fly Adhesion of Paper instead of Ply Adhesion brought forth this mildly hysterical flight of fancy in the Headquarters Standards Dept. The method is published as information only.

Standard Methods of Test for FLY ADHESION[1]

ASTM Designation: D 825 – 54

ISSUED BY MISTAKE[2]

These standard methods have not been approved by the sponsoring committee, nor have they been accepted by the Society in accordance with established procedures. Use them at your own risk. Suggestions for revision won't do much good, so don't bother.

Scope

1. These methods of test describe procedures required to separate flies of various kinds and sizes from grades of adhesive papers employed by the best people for Fly Adhesion.

Apparatus

2. One testing machine, consisting of an upper, movable grip and a lower, fixed grip, with a means of applying force to separate the grips and a recording dial calibrated in micrograms.

Procedure

3. Apply upper, movable grip of testing machine to fly adhering to test paper. Apply lower fixed grip to paper. Start the machine, and record the maximum load in micrograms required to remove fly. If fly breaks off at junction of grip and body, discard the results and find a new fly.

Report

4. The report shall include the following:

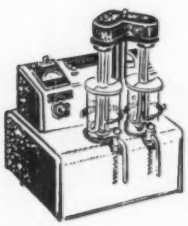
(*a*) Size and type of fly,
(*b*) Grade of paper employed,
(*c*) Maximum load in micrograms required to remove fly, and
(*d*) State of operator at end of test.

---

[1] Under the standardization procedure of the Society, these methods are not under the jurisdiction of any committee.

[2] Prior to nonadoption as standard, these methods were never published before, and it is hoped that they will never be published again.

rapid separation of metals
by mercury cathode
DYNA-CATH



For determination of aluminum in steel, aluminum in zinc base alloys, and other separations. This apparatus does a faster, more complete job in analytical separation of metals. Example Dyna-Cath quantitatively removes 1 gram of iron from 50 ml. of electrolyte in 20 minutes or less. Request Bulletin 220-F.

Eberbach CORPORATION
SCIENTIFIC INSTRUMENTS & APPARATUS
ANN ARBOR, MICH.

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OTHER SOCIETIES' EVENTS

March 3–6—**American Institute of Chemical Engineers,** Greenbrier Hotel, White Sulphur Springs, W. Va.

March 4–6—**American Railway Engineering Assn.,** Annual Meeting, Sheraton-Jefferson Hotel, St. Louis, Mo.

March 4–8—**Spectroscopy Society of Pittsburgh** and **American Chemical Society,** Conference on Analytical Chemistry and Applied Spectroscopy and Exposition of Modern Laboratory Equipment, William Penn Hotel, Pittsburgh, Pa.

March 7—**Cleveland Engineering Society,** 14th Annual Machine Design Conference.

March 11–15—**National Association of Corrosion Engineers,** Annual Conference and Exhibition, Kiel Auditorium, St. Louis, Mo.

March 11–15—**1957 Nuclear Congress,** Convention Hall, Philadelphia, Pa.

March 14–15—**Textile Research Institute,** Annual Meeting, Hotel Commodore, New York, N. Y.

March 18–20—**American Society of Mechanical Engineers,** Gas Turbine Power Conference, Sheraton-Cadillac, Detroit, Mich.

March 18–21—**Institute of Radio Engineers,** National Convention, Waldorf-Astoria Hotel, New York, N. Y.

March 25–27—**American Society of Tool Engineers,** Silver Anniversary Technical Meeting and Convention, Shamrock Hilton Hotel, Houston, Tex.

March 25–29—**Society for Nondestructive Testing,** Western States Convention and Technical Sessions, Ambassador Hotel, Los Angeles, Calif.

March 25–29—**Tenth Western Metal Exposition and Congress,** Pan-Pacific Auditorium and Ambassador Hotel, Los Angeles, Calif.

March 27–28—**The American Society of Mechanical Engineers,** Engineering Management Conference, Hotel William Penn, Pittsburgh, Pa.

April 3—**Society of Plastics Engineers, Inc.,** Regional Technical Confernce, "Plastics for Building," New York, N. Y.

April 7–12—**American Chemical Society,** 131st National Meeting, Miami, Fla.

April 8–10—**The American Society of Mechanical Engineers,** Spring Meeting, Dinkler-Tutwiler Hotel, Birmingham, Ala.

April 8–10—**American Institute of Mining, Metallurgical and Petroleum Engineers, Inc.,** Open Hearth and Blast Furnace Conference, William Penn Hotel, Pittsburgh, Pa.

April 8–12—**American Welding Society, Inc.,** Annual National Welding Meeting and Show with AIEE Conference, Sheraton, Bellevue-Stratford, and Benjamin Franklin Hotels, Philadelphia, Pa.

April 15–17—**Building Research Institute,** 6th Annual Meeting, Drake Hotel, Chicago, Ill.

April 16–18—**National Petroleum Assn.,** Semi-Annual Meeting, Hotel Cleveland, Cleveland, Ohio.

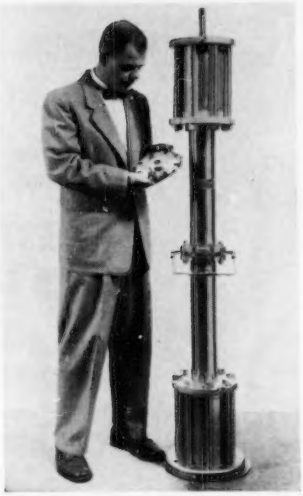
April 25–26—**American Society of Mechanical Engineers,** Railroad Conference, Sheraton Hotel, Chicago, Ill.

April 29–May 1—**American Oil Chemists' Society,** 48th Annual Meeting, Roosevelt Hotel, New Orleans, La.

April 29–May 3—**Society of Motion Picture and Television Engineers,** 81st Convention, Shoreham Hotel, Washington, D. C.

April 30–May 1—**Metal Powder Assn.,** 13th Annual Meeting and Metal Powder Show, Drake Hotel, Chicago, Ill.

Now you can shock test with a *controlled* 10,000-pound thrust



Using the HYGE shock tester, you can simulate actual service conditions to test the shock resistance of parts and assemblies.

You can set up the HYGE to produce specific acceleration and/or deceleration wave forms for desired durations.

Theoretically, the HYGE can produce a maximum build-up rate of 200,000 g's per second from zero to peak acceleration. The acceleration pattern is free of high-frequency transients.

The HYGE shock tester, manufactured and marketed by CEC under license from the Convair Division of General Dynamics Corporation.

How the HYGE Actuator works

Essentially a free floating piston in a closed cylinder, the HYGE gets its punch as the result of differential pressures on the two faces of its thrust piston. (See diagram.)

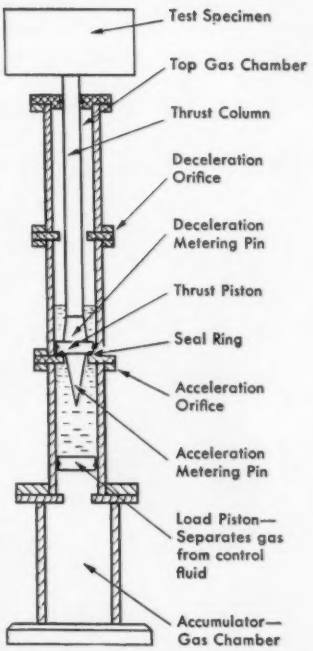
A low pressure in the top gas chamber forces the piston against a seal ring which seats on top of the orifice. Only the small piston area exposed to the orifice is open to pressure from the lower chambers.

By introducing compressed nitrogen into the lower chamber, you can equalize the forces on the two faces of the piston. Just a slight increase in pressure upsets this equilibrium, moves the piston up slightly, breaks the seal at the orifice, exposes the entire bottom of the piston to the high pressure of the lower chambers, and shoots the piston up with a terrific thrust.

Theoretically, the thrust will equal the difference in pressure between the upper and lower chambers times the net piston area exposed. This thrust is transmitted directly to the test specimen through a column.

The shape of the metering pin at the base of the piston regulates acceleration. Metering pins of different shapes produce different shock patterns.

To get controlled deceleration, add an orifice above the piston and another metering pin.



Several standard types of HYGE shock testers are available. There is also a "kit" of modular components from which a variety of units can be developed. Units can be combined to develop enough thrust for large test specimens.

Send for Bulletin P4-70 for a more detailed discussion of the HYGE shock tester.

Consolidated Electrodynamics
Rochester Division, Rochester 3, N. Y.
formerly Consolidated Vacuum

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Complete Electrophoresis Equipment

KLETT MANUFACTURING COMPANY

Manufacturers of Scientific Instruments

179 East 87th Street New York 28, N. Y.

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Take the guess work out of sieve analysis

SYNTRON

TEST SIEVE SHAKERS

—provide sieve analysis quickly and accurately. They eliminate all guess work and "rule of the thumb" methods of determining bulk materials particle sizes.

Sieve analysis aids in setting a standard for production and provides a permanent record of what reduction and screening equipment are doing. SYNTRON Test Sieve Shakers are equipped with a timer for accurate time testing. They are small, portable, and operate on ordinary 110 volt a-c.

Write for complete catalog Data—FREE

SYNTRON COMPANY

444 Lexington Homer City, Pa.

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STRAIN TESTER

performs elongation test on rubber (and other elastomers)

suspended in a free static condition as required by

ASTM Spec. D 1456-57T

Exact determination of modulus

SCOTT TESTER* Model SL

This Tester, as developed by the U. S. Bureau of Standards** and modified by Scott Testers, Inc., is standard for testing % elongation of elastomeric materials suspended in a free condition for a predetermined period of time, in conformance with ASTM specification.

Designed for accurate operation by nontechnical personnel. Operator simply revolves the additive weight control wheels to the number corresponding with the thickness number observed on the sample thickness gage—additive weight loading automatically follows.

Operator remains seated. Mirror system permits direct viewing and control. Test figure appears as a percentage of the original gage length—no computation.

4 stress ranges available: 50, 100, 200 and 400 lbs. psi.

Request Literature. Make use of our 57 years experience to help solve your testing problems.

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The proof is a matter of simple arithmetic. For example, for as little as $646.95 — often the cost of a single microscope alone — you may purchase *four* UNITRON microscopes and a photomicrography set. Shown here is a small selection of the many UNITRON models available.

METALLURGICAL POLARIZING BRIGHT-FIELD
STEREOSCOPIC PHASE PHOTOMICROGRAPHY

UNITRON POLARIZING — Model MPS

For the study and identification of material structure and characteristics. Revolving, centerable, graduated stage. Individually centerable objectives. Bertrand Lens for examination of interference figures. Coarse and fine focusing. Substage condenser. 2 compensation plates. Strain-free objectives: 4X, 10X, 40X. Eyepieces: Crosshair 5X and 10X, P15X.

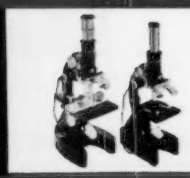
MPS $249

UNITRON METALLURGICAL — Models MMU, MMA

MMU: for metals and opaque specimens and also transparent specimens under both ordinary and polarized light. Vertical, oblique and transmitted illumination. Transformer housed in microscope base. Focusable stage, polarizing apparatus and filters. Objectives: 5X, 10X, 40X, 100X. Eyepieces: P5X, P10X, K15X.

MMA: a simplified version of MMU, 25 – 600X.

MMU $287
MMA $149

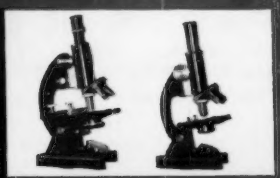


UNITRON PHASE CONTRAST — Models MPE, MPEA

MPE: Indispensable for the study of living cells and other highly transparent material. Continuous transition from phase to bright-field microscopy by adjusting condenser height. Choice of 4 contrasts. Mechanical stage. Three phase objectives: P10X, P40X, P100X. Eyepieces: 5X, 10X, P15X.

MPEA: a simplified version of MPE, 20 – 600X.

MPE $265
MPEA $99



UNITRON PHOTOMICROGRAPHY SET — Model ACA

Duplicates the performance of costly apparatus. Mounting brackets adjust to accommodate your present camera (35 mm., No. 120, No. 127, etc.). Viewing telescope permits all adjustments to be made while camera is in place and allows continuous observation of the specimen, even during time exposures.

ACA $39.95

UNITRON STEREOSCOPIC — Models MSH, MSL

MSH: for inspection, dissecting and other applications requiring a wide-field, 3-D view with great depth of focus. Inclined binocular head with distance and diopter adjustments. Revolving nosepiece. Choice of 3 objectives among 1X, 2X, 3X, 6X. Eyepieces: 8X, 12X, 15X. Models with both high and low stands.

MSL: single-magnification stereo with vertical binoculars.

MSH $267 up
MSL $110

These well known users are among the hundreds that have ordered — and re-ordered — UNITRON Microscopes. There must be a reason!

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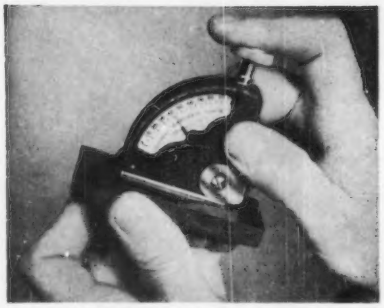

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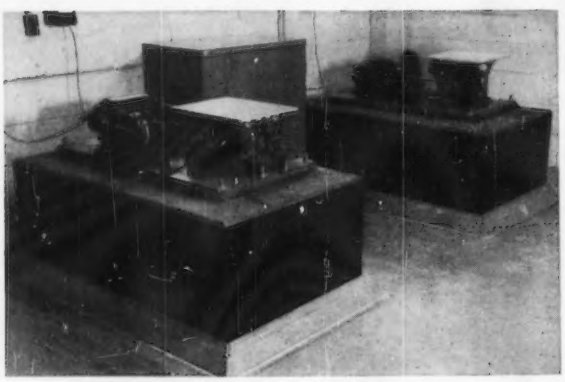

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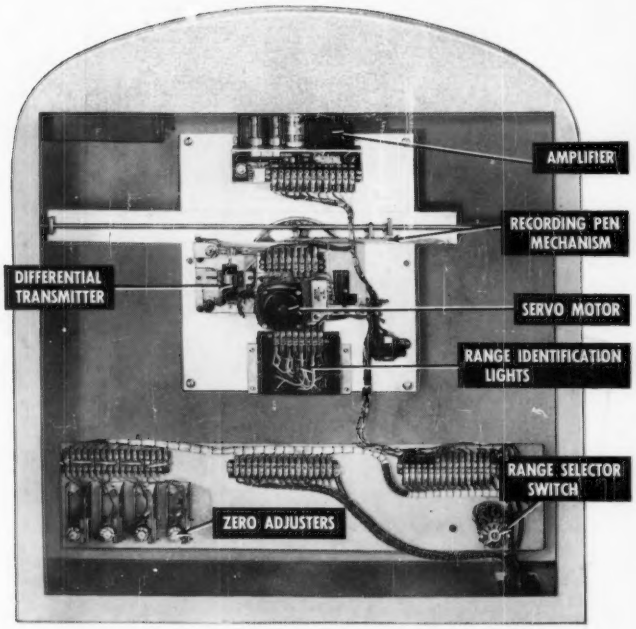

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